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PAYING AND NON-PAYING LOAD.

A paper read before the Civil and Mechanical Engineers' Society, by Mr. B. Haughton, C. E., on "The paying and non-paying weights pulled by the locomotive engine in 1867."

The railway statistics published by the Board of Trade, annually, as far as they go, are of vast importance in determining the quantity and cost of the useful work done by the locomotive. In a country such as the United Kingdom, possessing 14,247 miles of railway (or 22,091 miles of single line), which has been made at a cost of £502,263,000, equal to £35,253 per mile (or £22,736 per mile of single line); in which the receipts from railway traffic are £39,480,000 per annum, or £119,636 per day (in all such calculations I assume that the year contains 330 working days); in which 287,688,000 railway trips (not including those of season-ticket holders) are made in the year, equal to 871,781 trips each day, each trip 12¾ miles in length; in which 148,253,800 tons of goods, minerals, etc., are carried per annum, equal to 449,250 tons each day, each ton pulled over say 25 miles; in which 6,328,490 trains are started per annum, equal to 19,177 trains each day; in which the locomotive travels 148,542,827 miles per annum, or 450,129 miles each day; which has been the cradle of the railway, and in which it and its complement, the locomotive, were first invented, constructed, and brought into operation—in such a country the question of the administration and conduct of the railways must be a paramount one; and we cannot, as its people, be said to have done justice to this magnificent piece of mechanism until we shall have so investigated its economy, and the science of its action and effort, as to place beyond dispute the laws of its existence.

It is particularly desirable that such should be studied at the present day; there is, just now, a lull in the railway atmosphere; railway construction, incessant for the last 40 years, has at length ceased; the engineer is idle, the capitalist, without whose co-operation he dare not lift his hand, stands aloof; the public look on and suffer from the estrangement, and their occupation in this department of their manifold labors being gone (for the construction of 552 miles of single line per annum since 1827, with its attendant expenditure of £12,500,000 yearly, must have been to them a source of much and very profitable business); they began during their enforced leisure to examine and criticize the natural history of the giant that they have created, with the view to bending him to a more tractable and economic servitude; and, in truth, most wildly and inconsiderately have they approached the investigation. We cannot altogether blame them for having placed themselves so far under the guidance of *doctrinaires*. He who, by virtue of his office, ought to have been their guide in their attempt to solve the various questions at issue has not come forward to assist them with his counsel, and out of his practical and special knowledge of the situation. The engineer, which an immense material developement in the current century has produced, has been so entirely absorbed in, and devoted to, the physical side of the railway question, that he really has not had time to

consider its moral aspect. As soon as he shall have done so, and explained the condition of affairs, we may reasonably expect that the aforesaid public will become contented with "things as they are," as the intelligent British public always is, when light is given to it, and when it is made aware by the logic of facts that "things cannot be otherwise."

I hardly ever remember to have seen the truth so persistently distorted as of late, by certain pamphleteers, magazine writers, and ambulatory orators, in regard to this question. In one case a most elaborate literary picture has been drawn, in an article styled "The Great Railway Monopoly," the object of which appears to be to induce the Government to undertake the management of the railways of the United Kingdom; to confer upon the traveling public the benefit of low fares; and to prove indirectly the total incapacity of those who have the control and direction of the railway *menage* of the country. The article is remarkable for the display of much research, and, in short, conveys the idea that it comes from the hand of an accomplished and fluent compiler. It, however, reminds the engineer of a grand and boldly designed arch of masonry under construction; it is perfect as to the material selected, its foundations are on a rock, its abutments, its counterforts and haunches are undeniable, but it fails to support itself on the withdrawal of the centering, because of the omission of one simple, though indispensable feature—the key—which, in the case of this slap-dash article, must be supplied by the engineer, and the absence of which stamps the writer as being a literary conjurer rather than a practical man. With such instructors as these alluded to, and the magicians of the Belgian State lines, it is not to be wondered that the English public are disturbed as to the condition of their railways. It is not surprising that, at the first blush, they should believe themselves to be the victims of a selfish association of monopolists, and that this immense property is tended and controlled by an executive of quacks, who are guided by the leading idea that high fares alone will generate income; never was a more unfounded belief fostered.

The railways of the United Kingdom, at the present day, are conducted by an accomplished, scientific, and highly skilled body of experts, who know their business, do it, and don't talk about it, and who, moreover, take out of the locomotive all they can, and present it freely and exuberantly to those whom it is their interest, as well as their pleasure to accommodate—the traveling community; as shall presently be shown, this is, as the "Times" has lately stated, "the best served traveling community in the world," though I cannot endorse the final phrase in the sentence, that it is "the most ungrateful," because ingratitude is a vice of the weak and the unintelligent, and I cannot admit that my countrymen belong either to the one or the other class, but the rather that, having been made aware of the actual condition of affairs, they will accept it as being, on the whole, the best possible, considering all the circumstances of the case, and will unite with those who are only too well pleased to be assisted by them in concerting means for the elimination of such minor defects of the railway system as exist, and which are only those that belong to every human institution, but which, nevertheless, we must combat unceasingly, so as to attain as much perfection as our knowledge of the science involved will admit.

To begin, accordingly, the work done by the locomotive in 1867, the last year for which the Board of Trade returns have been published, was, viz:

3,924,624 passenger trains pulled 19.08 miles each.

	Tons.	Per cent.
Paying weight.....	27,472,368	4.89
Non-paying weight....	533,748,864	95.11
	561,221,232	100.00

2,403,866 goods trains pulled 30.64 miles each.

	Tons.	Per cent.
Paying weight.....	146,635,826	30.34
Non-paying weight....	336,541,240	69.66
	483,177,066	100.00

6,328,490 total number of trains pulled 23.47 miles each.

	Tons.	Per cent.
Paying weight.....	174,108,194	16.67
Non-paying weight....	870,290,104	83.33
	1,044,398,298	100.00

Horizontal mile tons.

Passenger trains	10,708,101,106
Goods trains.....	14,804,545,302
	25,512,646,408

This work was done by 8,619 locomotives, showing work done by each, per annum, 2,960,047 horizontal mile tons; work done

by each, per day, 8,969 horizontal mile tons, equivalent to 382 tons pulled 23.47 miles per day, and further, 17,234 miles run by each engine per annum.

Taking the 23.47 miles, the actual average distance run by each train per day, as consisting of an ascending gradient of 1 in 300 for half the distance, or 11.735 miles, and a descending gradient for the remaining half; and assuming 26 miles per hour to be the average speed of each train, equivalent to an exercise of horse-power, as under:

Train mileage of Board of Trade Returns.

$$\frac{148,542,827}{3,924,624 + 2,403,866} = 23.47 \text{ miles run by each train per day.}$$

Total train tons.

$$\frac{1,044,398,298}{3,924,624 + 2,403,866} = 165.03 \text{ tons' weight of each train.}$$

Average inclination, 1 in 300 up for 11.735 miles; and 1 in 300 down from the same distance.

Average speed, 26 miles per hour.

From these data are obtained the results:

$$\frac{26 \times 5,280}{60} = 2,288 \text{ ft. run by train in 1 minute.}$$

$$\frac{2,288}{300} = 7.626 \text{ ft. lift of train in 1 minute.}$$

$$\frac{165 \times 2,240 \times 7.626}{33,000} = 85.41 \text{ horse-power due to lifting the trains.}$$

$$\frac{165 \times 9 \times 2,288}{33,000} = 102.96 \text{ horse-power due to friction, etc., at 9 lbs. per ton.}$$

$+85.41 + 102.96 = +188.37$ horse-power required in ascending the incline.

$-85.41 + 102.96 = +17.55$ horse-power required in descending the incline.

$+188.37 + 17.55 = 205.92$ horse-power exercised throughout the average run of 23.47 miles.

Trains. Trains per day.

$$\frac{6,328,490}{330} = \frac{19,177}{8,619} = 2.22 \text{ trains pulled per day by each engine.}$$

Each train pulled 23.47 miles, at 26 miles per hour, gives 54.16 minutes occupied in the average journey.

$$54.16 \times 2.22 = \frac{120 \text{ minutes.}}{60} = 2 \text{ hours}$$

205.92 horse-power × 8,619 engines = 1,774,824 total horse-power exercised for two hours each day of 330 days per annum, in behalf of the traveling public.

Considering that these engines may be held on the average to be capable of exercising 400 horse-power each without forcing; the 206 horse-power actually made available will perhaps be considered too small a percentage to take out of each engine, but it will be understood that it is not possible to render useful the maximum power of the total number of engines in the country, for these reasons: that a certain portion must be held in reserve in case of ordinary accident to running engines; that another portion will be engaged as bank engines, and in shunting trains about the stations; that a large proportion of the whole will stand in the sheds for cleaning, and in the shops to undergo the repairs due to the daily wear and tear of an exceedingly complicated and perishable machine; and that, over and above all these requirements, an ultimate reserve will be necessary in order to make sure that a provision shall exist against all eventualities, and that in no possible case shall the company fail to perform their duties to the public punctually, as advertised in the time bills. These results cannot be taken as illustrating the work to be gotten from individual engines, but only as being useful in comparing the total work of one year with that of another in the same country; in comparing the work done in one country with that in another; and, above all, and eminently, in showing a people how much they take from their machinery in gross, with the object of exhibiting the weaknesses of the system, so as to effect such reforms as shall lead to improvements in organization and administration therefor.

In reviewing the foregoing figures, I shall ask your attention to two salient matters therein exhibited, the first of which is that I have reduced the work done to horizontal mile tons, and that I believe this to be the only true mode by which a railway company can accurately test the nature of its operations; and, secondly, to the extraordinary preponderance of the figures indicating the non-paying weight pulled as compared with the paying weight, viz: Firstly, the usual mode of estimating the work done, as practiced by boards of directors, is that by train mileage. The train mileage of one half-year, exceeds that of the corresponding half in the previous year, and this is hailed as a matter of congratulation from the chairman to his proprietors; or the increased income per train mile of the half year has exceeded that of the corresponding six months of the former year by a certain percentage, which is equally a cause of satisfaction to his audience; whereas, it is quite within the range of possibility, and has no doubt happened before now, that each of these apparently pleasing results of the half-year's work has been nothing less than a captivating illusion; for, in the first case given, that of an increase of train mileage, the

latter may have increased without bringing an increase of revenue, and may have brought with it a positive loss; and, in the second case, that of an increased income per train mile, the same may have arisen in consequence of a reduction of mileage, and may have existed co-incident with a falling off of revenue. The train mile is not a measure of the useful work done, because the weight of the train is not told; given the weight of the train, however, subdivided into its paying and non-paying weights, and a basis of calculation is afforded, which places the work done beyond cavil.

In order to attain this object, it will be necessary that the paying and non-paying weights of each train started shall be registered, as well as the distance traveled by each vehicle. This, though causing some extra office work, will amply pay for itself in the long run. I have endeavored to reduce the work done, as given in the Board of Trade statistical tables, to the horizontal mile ton by rating the weights of the average trains of the year as follows. It will be observed that some of the items in the tables are assumed. I have determined their value as best I could, from the most reliable sources I have been able to consult; the remaining items are taken from the Board of Trade returns, viz:

Weight of the average passenger train in 1867—

Non-paying load.		
Engine and tender	50 tons.	
Seven carriages	56 "	
Two breaks	10 "	
		116 tons.
Empty carriages, etc., to be pulled back, say ⅓th of above		20 "
Paying load.		
73 passengers, with luggage, etc., at 2 cwt. each		7 "
Total		143 tons.

I have chosen seven as a fair average figure for the carriages to each train. This number of composite carriages should contain, if full, 196 persons, narrow gauge; and in corroboration of this rating, I may quote Mr. Robert Stephenson, who, in his address to the Institute of Civil Engineers, in 1866, rated the then trains as capable of holding on the average 200, while not actually carrying over 100 passengers. It appears, from the Board of Trade returns, that the number of passengers has decreased since then, doubtless owing to competition, and the wish to render traveling more attractive by the running of an increased number of trains, since only 73¼ passengers were carried per train in 1867; or it may have been more directly due to the practice of sending through carriages to all the principal stations with the more important trains, thus saving their occupants the necessity of changing from one carriage to another *en route*. The empty carriages to be pulled back with their attendant portion of the weight of the engine, consequent on the irregularity of flow of the streams of traffic in opposite directions, is a fact that cannot be evaded, I have rated it at one-sixth the non-paying weight.

Some persons may take exception to the rating of the assumed items, but, even should they be found strained or faulty, which I have taken all pains to prevent, the amount of their error, however largely it may be estimated, cannot materially affect the issues.

Weight of the average goods train was, in 1867—

Non-paying load, viz:		
Engine and tender	50 tons.	
Two breaks	8 "	
Six goods trucks at 3½ tons each, to carry 3 tons	21 "	
Six mineral trucks at 3¼ tons each, to carry 7 tons each	21 "	
		100 tons.
Of the above, to be sent back as empties, two goods trucks six mineral trucks	28 tons.	
One-fourth engine and tender, with empties	12 "	
		40 "
Paying load.		
Goods	19 tons.	
Minerals	41 "	
Six and a-half head live stock	1 "	
		61 "
Total		201 "

In this table the detail of the item 61 tons is taken from the Board of Trade returns; the other items are assumptive (under certain restrictions, which will be apparent), still not to be omitted. These two tables give the average weights of the passenger and goods trains of the year; by multiplying their several sums by the total numbers of trains, passengers and goods respectively, run in the year, as given in the returns, I have arrived at the great totals given before.

The second point to which I have asked your attention is that of the immense excess of the non-paying weight of the trains over and above the paying weight. This is a

subject which is frequently treated in the scientific publications of the day, and which has been discussed at meetings of this Society, but I am not aware that it has been hitherto considered in connection with the Board of Trade returns. In the annual address, which I had the honor to give to this Society in October, 1868, I alluded to the subject of non-paying weight. I then gave an estimate of what I believed to be the proportions in which these two divisions of the total weight of the train are to be found. The non-paying weight, large as it was, I now find was understated, as shown by the astounding results extracted from the returns. This was in part owing to the fact that the figures were drawn from a much smaller railway circle than that from which the returns immediately before us have been computed.

The proportions of the paying weights of trains run in 1867 were, viz:

Passenger trains.
Paying weight, 4.89 per cent of the total weight of the train.

Goods trains.
Paying weight, 30.34 per cent of the total weight of the train.

Total Passenger and Goods trains.
Paying weight, 16.67 per cent of the weight of the whole train.

Or, in simpler phraseology, it takes 19 tons of train equipment to carry one ton of passengers, $2\frac{3}{4}$ tons of the same to carry one ton of goods, and, in gross, 5 tons of equipment to carry one ton of paying load.

That the public are not acquainted with these facts is, I believe, the secret of their discontent with the management of our railways. They place themselves willingly under the direction of theorists, who are not competent to realize the situation. Relieve them from this state of suspense in which they are placed, make them familiar with the reason why they cannot hope for a reduction of fares, and they will rest content, and railway property cannot fail to be the gainer thereby. Show them that the experience of the Post-office cannot be taken as a guide for the management of railways, because a letter weighs practically nothing, as I have endeavored to show in the address before mentioned, and that its numbers may be increased almost indefinitely without extra cost of carriage, whereas a passenger will weigh two tons, including his share of train equipment; and, moreover, that each passenger carried, in addition to the usual numbers, will bring an additional weight of two tons with him. Show them that the fares charged by excursion trains cannot be taken as a guide, because the conditions under which they are run are not those required in the conduct of the common traffic trains of the country. Show them that the extremely low fares charged on the Belgian railways cannot be taken as a guide, because, firstly, what are commonly called the Belgian railways, and notably so in the second report of the Railway Commission of 1868, are not the Belgian railways, but only a fraction of them, that is to say, 535 miles out of 1,819; secondly, that they were constructed by the Government, before private railway enterprise had commenced in Belgium, who naturally selected the most promising lines of country, and are, in fact, possessed of the cream of the traffic of the land; thirdly, that these lines have cost £18,000 a mile as against £36,000 for the English lines; fourthly, that these lines have been charged with no parliamentary expenses; fifthly, that land is of far greater value in England than in Belgium; sixthly, that labor is dearer in England; seventhly, that the speed of the Belgian trains is considerably less than that usual in England. That all these things combine to make the working of railways more costly at home, and so to produce higher tariffs of fares and rates; and, finally, that no later than this month, M. Malou, Belgian senator, and well versed in the railways of that country, has shown, in a pamphlet which he has published, that the glowing promise of a new railway era, to be inaugurated by these gifted Belgian legislators, is only a juggle and a delusion, and that the Government must immediately raise their fares considerably, unless they are prepared to work their 535 miles of line, having cost £10,000,000, with an utter disregard of the ordinary principles of economy and trade, and at an enormous loss per annum. Lay all these facts and views of the question before the traveling public of England, and they will quickly wipe the film from off their eyes that now rests there, and be led to confess that, after all, the men who have invented and perfected the locomotive and the railway, with its belongings, and instructed the world in the art of working and using it, are as likely to know how to tend, and direct, and manipulate it with skill and sagacity, as are their continental and other pupils.

The English engineer knows that natural

and economic laws must eventually prevail, no matter how the public may wish to dispense with their action; he knows the ways, paths, and tendencies of these laws; he knows how to respect them, as respected they will be; while he also knows how to bend them to his educated will. With these laws as his guides, and with the forces which nature permits him to wield as implements, he goes on in a safe and sure road of progress, and, as he advances, hardly turns his head to reply to the dreamers and triflers, who preach from the stump and the journal the reversal of the order of nature.

This immense dead or non-paying weight has ever been a difficulty with the engineer. Dead weight has no doubt increased of late—engines are made heavier, hence more adhesion, less liability to become derailed, and greater economy of fuel in working; carriages are made longer, hence there is more space for the legs of passengers; they are made higher, hence more facility for moving when in an erect position; the timber is of large scantling, hence more steadiness and durability—all these changes have been changes for the better, the traveler, in consequence, is more convenienced as well as physically safer than before—the latter a boon that cannot be over-estimated; he is actually 1,000 per cent safer at present sitting in a railway carriage in motion, than when walking in the London streets. The Briton of the age, in short, travels fast and securely; faster, indeed, than the representative individual of any other nation; he is in the condition of the man who lives fast, and builds a large and comfortable mansion for his gratification; its dimensions are greater than are absolutely necessary for his wants, yet he can afford the cost and he defrays it. The Briton must do likewise if he wishes to travel fast.

Reduction of non-paying weight is practicable, but it implies a reduction both of the rate of speed and of convenience, and it is not likely that it can be attempted in the face of the long enjoyment of these luxuries which the public have possessed. The receipts per mile from the 73¼ persons who traveled per train run in 1867, were, viz:

	Persons.		s. d.	Corrected income per mile.
1st class.....	8¼	at 2d. per mile,	1 4¼	1 2¾
2d class	20	at 1¼d. "	2 6	2 3
3d class	45	at 1d. "	3 9	3 8
	73¼		7 7¼	7 1¾

The column headed "Corrected" shows the correct figures, having made the proper deductions because of return tickets, which may be taken at 60 per cent of the whole number of tickets issued for 1st and 2d classes. This 7s. 1¾d. per mile must not be confused with the 4s. 9d. per train mile of the returns; the first is the income per mile run by the 73¼ passengers, the average mileage run by each passenger being 12¾ miles, while the average mileage per train was 19 miles.

The following details may be useful, viz: 73¼ passengers carried in each of the 3,924,624 passenger trains run. Paying and non-paying weights of each train 143 tons, being a total weight per passenger of two tons. Total weight of train per one ton of passengers equal to 20 tons 8 cwt. 60 tons goods and minerals, and 6½ head of live stock carried in each of the 2,403,866 goods trains run, paying and non-paying weights of each train 201 tons, being a total weight per one ton of freight of 3¼ tons.

Each passenger train, weighing a total of 143 tons, was pulled over a distance of 19.08 miles, bringing a revenue of £4 11s. 4¾d., equal to

	d.
Per mile ton of paying weight.....	8.2
Per mile ton of total weight of train.....	.40

Each goods train, weighing a total of 201 tons, was pulled over a distance of 30.64 miles, bringing a revenue of £8 19s. 2¾d. equal to

	d.
Per mile ton of paying weight	1.14
Per mile ton of total weight of train.....	.34
Passengers revenue per head per train mile..	.78
Passengers revenue per head per mile actually run by each passenger.....	1.17

These figures lead to the vexed question, viz: the relative paying properties of passengers and goods, which is shown in the items, as above, viz:

	d.
Passenger revenue per mile ton of total weight of train.....	.40
Goods revenue per mile ton of total weight of train	.34

These figures are not strictly accurate, while sufficiently so for our purpose, because we know from the passenger revenue per head per train mile of .78d., that each passenger cannot have traveled the whole 19.08 miles run by the passenger train. I find that the actual distance run by each passenger was about 12¾ miles, or three-quarters more than the distance run in 1855, as given by

Mr. Robert Stephenson in his address to the Institute, in 1856, before alluded to. The precise distance run by each ton of goods pulled is not so easily found. However, all things considered, the deductions for these drawbacks of passenger and goods mileage from the 19 miles and 30¾ miles run, will not cause any material error in the representative fractions .40d. and .34d., the incomes per horiz. mile ton, respectively, as the deductions would only apply to the paying weight sections of the train, which in each case is small as compared with the total weights.

These fractional figures would place the advantage on the side of passenger traffic to the extent of .06d. per horiz. mile ton, but against such is to be placed the serious debit of 90 per cent more speed, also 90 per cent more of capital invested in vehicles, valuing carriages at £200, and trucks at £60 each, the capital invested in the latter being, viz:

Carriage capital, per ton of freight pulled per annum ..... 3s. 9d.
Truck capital, per ton of freight pulled per annum ..... 2s. 0d.

While to its credit is to be placed, say, 50 per cent less concussion, and the carrying of 75 per cent more freight per vehicle, etc., viz:

27,354 carriages carried 27,472,368 tons, or 1,004 tons per vehicle.
247,048 trucks carried 146,635,826 tons, or 593 tons per vehicle.

A debtor and creditor account would stand thus—

PASSENGER TRAFFIC,
AS AGAINST
GOODS TRAFFIC.

Dr.	*Cr.*
90 per cent more speed.	17 per cent more revenue per mile ton of total weight pulled.
90 per cent more vehicle capital invested per 1 ton of paying load pulled.	50 per cent less concussion, viz: load carried 12 cwt per foot of wheel base, as against 20 cwt. to 40 cwt.
	75 per cent more paying load carried per vehicle per annum.
	12 per cent greater facility in reception and delivery of paying load.

I shall not now strike the balance; the advantage, however, at first sight, is on the side of goods traffic. If the two sides should be found on a line, it will be a remarkable proof of the sagacity of railway managers, in that they succeed in making the two great divisions of traffic revenue contribute equally to the general account.

I must not forget to acknowledge my obligations to Mr. Frederick T. Haggard, of Burnham House, Kent, for the assistance which I have received from him while investigating this question, as well as for the hints which I have taken from his valuable pamphlet, entitled "A Mile of Railway," published last February.

The moral which I have endeavored to make this paper convey, is this: that so long as the railways of the United Kingdom shall carry passengers and their train equipage at .40d., or two-fifths of a penny, per ton per mile, at an average speed, while running, of 34 miles per hour, and goods and minerals, with their accompanying dead weights, at .34d., or one-third of a penny per ton per mile, at a speed of 18 miles per hour, the public cannot complain.

If they will take a common sense view of the question, and compare these rates and speeds with those of such other modes of traction as they are familiar with, and further, compare them with those of other countries, giving their own country credit for the many and great conveniences and accommodations which the system confers upon them, as well as taking due cognizance of the quality and price of the material out of which the fabric is made, and upon which it is built up, I feel assured their verdict will agree with that before quoted—that in the matter of railways they are "the best served community in the world." These returns disclose the strange facts that the average British passenger weighs two tons, with train accessories, and that the ton of goods, etc., weighs 3¾ tons; by no known processes can these enormous multiplication of original net weights be reduced, consistent with affording that amount of personal security, and comfort, and accommodation now enjoyed; let them, in their future deliberations on this subject, relinquish the idea which has so long clung to them, and which has been so ingeniously and persistently placed before them, that a railway passenger is a featherweight—a letter or a newspaper, as it were—and that he may be treated accordingly, let them try to realize the facts as stated, as to the actual total of paying and non-paying weights pulled, and the enormous energy developed in order to produce the effect expressed in the figures as before given, viz: 25,512,646,408 horiz. mile tons.

These, combined with the figures representing the wear and tear of material, and the labor expended in the maintenance of the system, will, perhaps, convince them of what an exacting, devouring, and insatiable monster it is that they have called upon to minister to their lately-born wants, and will go far to reconcile them to the existing tariffs of fares and rates, which, no doubt, competition and the wish to act in a just and liberal spirit to all parties concerned, on the part of railway executives, has already reduced to the lowest admissible rate. I believe that these are amongst the "things not generally known," and that when generally known they must tend to promote and strengthen that cordial understanding which ought to exist between the railway proprietor and the traveler by railway, and so without fail to increase the confidence of the investing public in this great property, and as a necessary sequence, to enhance its money value.

THE FAIRLIE STEAM CARRIAGE.

From the "Mechanics' Magazine."

The name of Mr. Robert F. Fairlie has, for some time past, been brought prominently before the public in connection with the economical working of railways. The Fairlie engine is well known to our readers, and a brief description of his steam carriage has also appeared in our pages. A trial of this carriage was made July 15th, at the Hatcham Iron Works, which successfully demonstrated the practicability of working the system upon railways, with curves of only 50 ft. radius. The steam carriage exhibited, and which was not quite completed, was designed to work on a metropolitan railway, at the terminal stations of which sufficient space could not be given for laying down rails on a curve of 25 ft. radius for the standard carriage to run itself round; consequently, the standard carriage had to be altered in dimensions to allow of its being turned on an ordinary 40 ft. turn-table. Hence, instead of seating, as is intended, the 100 passengers in the standard carriage, the carriage under trial only gave seating space for sixteen first class and fifty second class, in all sixty-six passengers. The accommodation per passenger is as good as is given on the best lines, and infinitely superior to the stock usually worked on branch lines. The length of the carriage is 43 ft., including a compartment near the engine for the guard. The engine, carriage, and framing all complete, in working order, but exclusive of passengers, weighs under 13½ tons, and including its full load of passengers, 18½ tons only. The carriage when finished complete will have a broad step or platform on each side, extending its entire length; this step is protected by a hand rail on the outside, with an arrangement for lifting it on the platform side at the doors to allow the passengers to get in and out. The object of this platform is to enable the guard to pass completely round the train at all times, and while doing so, he is perfectly safe from any accident. Passengers can also pass along the platform to the guard, so that in this manner there is an easy and perfect mode of communication between passengers and guard.

It is intended, however, in the standard steam carriage to provide a central passage inside the entire length of the carriage, leading direct from and to the guard's compartment; thus there is the most direct means of communication between the passengers and guard. The compartments in the carriages will be quite as separate and distinct as they are at present, or as the most fastidious could desire. The guard passes through the carriage at pleasure. Those in the higher classes can pass to the lower, but the lower cannot get to the higher, while all can pass to the guard when required. The standard carriage will have two compartments first class, to seat 16 persons; three compartments second class, to seat 30 persons; and four and a-half compartments, third class, to seat 54 persons—in all, 100 passengers. The machine complete, in working order, will weigh about 14 tons, and with the 100 passengers, from 20 tons to 21 tons. These carriages will convey their full complement of passengers at forty miles per hour up gradients of 1 in 100, and, as demonstrated, will pass round curves of 50 ft. radius at twenty miles an hour with perfect safety.

There are few trains on any of our railways which convey more passengers per mile than can be accommodated by one of these steam carriages. In fact, it is known that the average number of passengers, taken from the Parliamentary returns, give only about eighty passengers conveyed altogether by each passenger train in the United Kingdom, from the time it starts until it completes its journey; and this only gives about an average of 30 to 35 passengers at

any one time in the train, for each mile traveled. Of course, there are exceptions to this number on our principal mail lines, but even in these cases, a greater number is the exception, and not the rule. The weight per wheel of the steam carriage being only about 2½ tons, it follows that very light rails may be used, with everything light in proportion. The passage of such sharp curves so easily will enable us to make lines very inexpensively; we need no embankments or cuttings or heavy masonry works of any kind; therefore, lines will be made cheaply and stocked cheaply. Under these circumstances, there is no reason why every village should not have its line either direct or communication with some of the main lines, to which these light railways would act as feeders, and not like the present branch lines, which really act as suckers and not feeders. Many of these branch lines have actually cost a larger sum per mile than the parent line, over which the traffic from the particular branch would not represent more than 5 per cent, if so much, of the total traffic. Then how, in the name of wonder, can such lines pay? When a gentleman desires to open up an estate for building or agricultural purposes, the first thing he considers is the making of suitable roads through it. Now, instead of roads, there is no reason, why these light railways should not be made. In time it will come to this.

We are only, in a sense, beginning railways; we must have double, aye, treble the mileage we have at present, but every one of these miles must not only be constructed but worked in a very different manner to that in which they have been, and are being at present. We have only to consider this simple fact: the steam carriage, with 100 passengers included, weighs about 20 tons, while the tender which accompanies the ordinary locomotive, and which is perfectly useless, except to carry food for the locomotive, weighs as much, if not more. The usual passenger trains average in weight, exclusive of passengers, about 80 tons; therefore, it follows if to work 80 tons it takes 30 lbs. of fuel for the locomotive per mile, to work only 20 tons, one-fourth of the fuel would be required. The reference to fuel means oil, tallow, and every material required to maintain the engine; it means also the same proportionate reduction in the cost of maintenance of permanent way, and all charges connected with the working of railways. The proper method of working railways is to take the largest possible loads, and, consequently, fewer numbers of goods trains; so that instead of earning about 6s. per train per mile at a cost of 50 per cent, netting 3s., these should earn double the amount—say 12s. per mile—while the cost would not exceed 1s. over the 3s. spent to earn the 6s., giving a net production of 8s., instead of 3s., or about 280 per cent more.

Then, again, the passenger trains which now earn under 5s. per train per mile, and costing 50 per cent of the amount, or 2s. 6d. to earn it, could be worked with the steam carriages at a cost of about 1s. 6d. per mile, thus adding 40 per cent to the net receipts on passenger traffic. It is to be remembered that these percentages are pure gains to railway companies, the cost of management and other charges being taken as remaining the same, the profits arising solely from the improved mode of working. The Fairlie engine can haul double the ordinary loads of goods per train, without injuring the permanent way so much as is now done by the ordinary engine; and allowing for the increase in the consumption of fuel for the load taken, all other expenses remaining the same, the extra cost on each could not exceed even 6d., although 1s. is placed against this item—therefore, the profit must certainly be very great.

While on the subject, we now notice the Fairlie engine "Little Wonder," which has been built for the Festiniog Railway Company, and which has obtained very considerable notoriety from its being the narrowest gauge passenger railway worked by locomotives in existence. The line has been worked now about five years, and during that time there has not been the slightest accident of any kind; in fact, it is considered a most extraordinary line, not only on account of its gauge, which is only 2 ft., but because of its success commercially. The traffic hauled last year over this miniature line of twelve miles in length amounted to 130,000 tons of goods, and 145,000 passengers, which would be considered a very handsome traffic for a full-sized railway of the same length, and the wonder is, how it has been done. The credit is due to the able management of Mr. C. E. Spooner, managing director and engineer. The traffic has so increased that the ordinary engines are getting too small to pull the loads, and hence the adoption of the Fairlie

engine, which at once enables the train loads to be doubled, without, but in a very small degree, increasing the cost of each train. The Festiniog line is, for about eleven miles, one continuous ascent of about 1 in 80, with very many curves, some of which are as small as 100 ft. radius. The "Little Wonder," although weighing but 19½ tons, fully equipped with fuel and water for the road, will haul after it 140 tons, at a speed of fifteen miles an hour for the whole eleven miles; a feat, considering the gauge and weight, that could not be accomplished by other than the Fairlie engine. The engine has eight wheels, in two separate groups of four each, each group being acted on by a pair of cylinders 8½ in. diameter. The wheels in each group are 2 ft. 4 in. diam., and are coupled together.

The extreme wheel base is 18 ft.; consequently, the engine will run with remarkable smoothness. At the same time, the wheel base of each bogie being but 5 ft., the engine will pass round curves of 50 ft. with the utmost safety at 20 miles an hour. The principle in this respect is precisely similar to that of the steam carriage passing curves of 50 ft. The fact of either steam carriages or engines being constructed to run with perfect safety round curves of 50 ft. is unprecedented in the history of railways, and places the railway world under a considerable obligation to Mr. Fairlie, who has spared no pains to perfect a system to which we wish every success.

ACCUMULATED HYDRAULIC POWER.

From "The Engineer."

The advantages in economy and convenience which attend the use, for many purposes, of accumulated power, are by no means generally understood. By accumulated power we mean power which is generated continuously, to be used at intervals without any change in the application, such as occurs in the use of a hammer, where the accumulated power is used percussively. In this case there is such a sudden application of the accumulated power as to cause very marked differences in effect from the effect of the same, were power applied in any other way; in fact, it is well known that for certain purposes it is imperative to apply power percussively; but the purpose of the present article is to deal exclusively with the question of the periodic use of continuous power as affecting the economy and convenience of machines used for manufacturing purposes. Power may be accumulated in very various ways, but it is in the hydraulic accumulator that we find the most extensive and convenient application of the principle. To the application of hydraulic accumulation we shall therefore confine our attention, and, further, we must premise that direct applications of hydraulic power, as in the hydraulic jack, do not bear upon the question, as we have in all such cases a concentration of the power, it is true, but no accumulation.

Five points have to be considered in relation to the subject in hand, namely—(1), the cost of generating the power; (2), the loss by friction; (3), the cost of the machinery; (4), convenience of application; and (5), the cost of maintenance.

The cost of generating the power should be taken as including all expenses incurred in the prime mover and the pumps and accumulator, as the power developed by the prime mover is, till transferred to the accumulators, of no more avail than if none existed. Very erroneous statements have been put forward as to the cost of pumping into accumulators, such statements being usually based on the duty performed by pumps working at lower pressures, such as are required for work of a totally different kind. The friction in pumps working at low pressures very much exceeds in proportion that of hydraulic pumps working at high pressures, and we shall be able to show that the percentage of friction rather diminishes than increases with the pressure, even at high pressures. Further, the amount of power accumulated will increase as the differences of the squares of the diameters of the plungers, but the friction of the plungers only increases as the first power of the differences of their diameters. On this ground, pumps of large diameter and short stroke seem most desirable, but the frequent opening and closing of the valves, and the greater strength of the framing and gearing required with such increase of diameter, must be weighed in practice, and a line drawn beyond which this theory must not be pushed. The increase of friction from the increased strength of gearing cannot be stated otherwise than by a reference to each particular case, but a little consideration will make it evident that this increase bears but a small proportion to the diminution of the friction on the plungers, because the speed of the moving parts is in the inverse ratio of the squares of the diameters of the plungers, while the increase

of the frictional surface will be in the direct ratio of the diameters. It may be taken roughly that the increase of friction in the gearing will be directly as the increase in the diameter of the plunger, and the diminution in the friction of the plunger in a like proportion. There is one other element of friction to be considered ere the power accumulated is available for use, namely, that due to the passage of the water through the pipes, forming the communication between the accumulator and the machines which use the power. This friction is but little increased by the length of such pipes, but is very seriously augmented by all indirect-passaged valves, sudden bends, and all alterations of the form or area of passage. Of these and other kindred points we shall speak more fully in future articles when we come to discuss the designing and making of hydraulic apparatus. Having reviewed these preliminary points, we can now pass to the consideration of the great source of economy incidental to the use of accumulated power for intermittent work, such as punching, shearing, forging by dies, bending and straightening metals, hoisting, pressing and packing, and many other processes. The chief source of economy lies in the use of a far smaller prime mover than could otherwise be used, such prime mover working against a continuous and equal load, and therefore, *cæteris paribus*, working economically. Fully to appreciate this advantage it is necessary to bear in mind, that the saving in the size of the prime mover is in direct proportion as the intervals of rest of the machines exceed their intervals of work, and is at a maximum when the work is regularly intermittent, and of the shortest duration as compared with the intervening period. It naturally follows, therefore, that heavy work requiring some time for its intermediate handling and preparation, followed by the exertion of excessive pressure through a small range, offers the most economical field for accumulated power. As the intervals of rest grow shorter the economy diminishes, but not necessarily the convenience. To make our meaning plainer, let us take the case of shearing and punching plates, requiring, say, fifty-four seconds each to place in the tools, and the application of a power for six seconds equivalent to raising 500 tons through 1.2 in. In round numbers, 34-horse power will be the power developed for six seconds. Now, supposing a water-wheel or steam engine to be the prime mover used, we should require one of 34-horse power continually at work, during only one-tenth of which time would it do any useful work; with an accumulator, on the other hand, one of 3.4-horse power would do the work. It will be seen, therefore, that we save the power absolutely lost in driving the larger engine or wheel for nine-tenths of its time, the interest on its first cost, and the extra room it would require. In each case, to a small engine or other prime-mover, pumps of equally small size will be required, but the size of the accumulator depends on other data. By the following method the proportionate sizes of each part of the hydraulic apparatus may be fixed: The work to be done in, say, one hour or one day, must be estimated; then a prime-mover must be fixed upon capable of doing this work per hour or per day, and, as before stated, the size of the prime-mover will indicate the capacity of the pumps. The capacity of the accumulator must be arrived at by estimating the duration of the longest interval of rest, and then calculating the size of the accumulator to hold the full quantity pumped during that time. After the capacity of the accumulator has been arrived at, it will be necessary to determine what length of stroke shall be adopted. This will involve important practical considerations regarding the load to be carried, and its momentum in falling when water is drawn by the machines. The power remaining the same, the pressure per inch will exercise a considerable control as the designing of the pumps and accumulator. We shall defer treating these points in detail, as our space will not, in the present article, admit of more than a general treatment. We now come to a very important point in the use of hydraulic machinery, namely, the cost of machines themselves and their size. In the first place, we note that well-designed hydraulic machinery for the various operations before mentioned is very simple in its constructive details as compared with geared machinery, is also much smaller and lighter than other machinery of equivalent power, and exhibits a much lower percentage of friction. It is also a fact that as the power is increased, these three advantages of simplicity, lightness, and small frictional coefficients, become more and more marked as compared with other contrivances of corresponding power. Of course, cost in machinery is considerably dependent on simplicity of parts, and it will be found that in all cases where hydraulic machines have been properly de-

signed and made, the first cost and the cost of maintenance have been small, compared with other machinery of equal capacity. The chief item of expense in the maintenance of hydraulic machinery lies in the cost of renewing the cupped leathers; and from want of a little good bainwork in the design of the machine, the cost of putting in the latter is often far more than the cost of the leather itself—in fact, it is the writer's experience that this is the rule rather than the exception. It is also very noticeable in most cases that the leathers do not have a fair chance of a long "life" by reason of the inferiority of the surface against which they work, arising from "specks" and deficiency of finish. It is very difficult, nay, even impossible, to get a perfectly clear surface on cast or wrought iron by ordinary tools and operations; but much may be done by the adoption of little practical "dodges," of which we shall have occasion to speak hereafter. The consideration of the convenience of hydraulic machinery opens up a very wide and interesting field of applied mechanics; but one rather difficult to treat of generally, as each individual case offers some distinctive features of its own. Yet we can select certain salient features which may serve as mental standpoints from which to regard isolated cases, which may arise in each branch of manufacture. In all cases where it is a necessary part of a process to have a machine to stand for accurate adjustment of the work, as in punching, shearing, etc., accumulated hydraulic power is very advantageous, as the tools can be brought close to the work and kept at any point quite steady till the adjustment is complete, when the blow can instantly be obtained. There is also the very great advantage that the pressure can be kept equally on the work, and will follow it up self-acting, which other gearing will not do satisfactorily. There is one point of superiority in hydraulic pressure from an accumulator which in many operations is eminently important, and which is equally characteristic of it, and that is, that if the "work" will not yield, there is not an increase of pressure, as in other cases, and therefore no risk of such an increase of strain as to break the machine. No doubt many of our readers have seen numerous cases, in machines which possess momentum and have to pass a dead center, of ruinous fractures, due to some impediment which has got in and tended to stop the machine. In such a case there is an instantaneous conversion of the *vis viva* of the machine into a force which often becomes disruptive. As an instance, the fractures of screw-heading machines may be taken; nor are such instances uncommon in ordinary shearing machines. There is no remedy for this difficulty other than to adjust the strength of the machine so as to be capable of suddenly absorbing the *vis viva* of its own moving parts. This, however, cannot always be done. Hydraulic machines, on the other hand, require only to be constructed capable of bearing the normal strain of the work, as such strain cannot, in the very nature of the case, become abnormal. In all cases where a large power is required to be put on a small area, hydraulic power offers great advantages, as small, accessible, and easily controllable tools of immense power can thus be obtained; but in some cases peculiarities in the work modify these advantages so far as to preclude this successful application, as for instance, where it is imperative to have a long traverse with very little work except at the end of the stroke. In such a case the great waste of power would preclude such an arrangement, except in cases where convenience was a paramount question and power of little value. It is in dealing successfully with such questions of suitability that the engineer can show his grasp of his profession, and on such fields do the masters of the credit meet and overthrow the mere charlatans and men of a "groove."

EXPLOSIONS OF NITRO-GLYCERINE.

From "The Engineer."

After referring to the late disaster in Wales, our authority proceeds as follows: Our object is not now to discuss the unfruitful question of what brought about this disaster, as its proximate and immediate cause, but to offer a few practical remarks with a view to prevent the recurrence of others, based on a somewhat more precise knowledge of the properties of the substances concerned than appears possessed by the "correspondents" of our various contemporaries, or by anything brought before the "crowner."

Since the introduction of nitro-glycerine to practical use, at least half a dozen tremendous explosions of it have taken place in Great Britain, several in America, and a few in Germany and France. Their effects in destroying life—with circumstances as sudden and inevitable, and more appalling

than death by lightning—have filled the imagination of all who have listened to or read accounts of them with inexpressible dread of this tremendous agent; and it is quite likely that at the motion of some of our legislative wise men—of the kidney of those who would abolish patents because they hamper some people and tend to produce lawsuits—some attempt will be made to interdict the use of nitro-glycerine as a blasting agent in our country; or so to restrict the conditions for its storage and transport as to diminish, or even neutralize, its enormous advantages to the quarryman, the miner, and the tunnel-driver.

We do not for a moment contend that some legal and police regulations as to its manipulation in storage and transport are not most desirable; on the contrary, we say at once, the necessary powers for *codifying* and rendering such stringently operative ought to be taken, and immediately applied. But let us first clearly ascertain what such regulations should consist in, and how far they need go.

If nitro-glycerine, like tri-nitro-cellulose or gun-cotton, be badly prepared—we shall not here go into any chemical particulars—it may pass into a state of incipient decomposition, and of chemical condition so unstable as to explode—as we may popularly, but still not with philosophic accuracy express it—spontaneously.

Against this the only real safeguard must be the skill, fidelity, and reputation of the manufacturer; and were proper means taken to prevent extraneous and other causes of explosion, the makers of nitro-glycerine would see that it was to their own interest to send out nothing but such as was, in this respect at least, safe. In fact, we have no doubt that, as far as any tendency to explosion of this sort goes, as much may be done for nitro-glycerine as Mr. Abel—following after Von Lenck and others—has done for gun-cotton, which once had, and somewhat justly, a bad character in this respect.

But, secondly, let us ask, on behalf of nitro-glycerine, is it to be supposed that more than seven hundred years ago—when gunpowder first began to be practically employed as an explosive agaent—that there were not many and terrible so-called accidents attending its use? Such must be the course of events with any new and powerful agent suddenly brought into popular handling; and such must equally tend to disappear as popular ignorance gradually gives way to rapidly diffused information as to the properties of the newly-acquired agent. Well, what remains, then? That we can and ought so to guard against, as serpents, the properties of this new agent, so enormously more powerful when exploded—and as exploding by concussion, so unquestionably more dangerous than gunpowder.

To say in sufficient detail all we could say, and at the proper place, should be prepared to say on this, would far outstep the limits of a leading article, but it may be all condensed into one general sentence—so store and so transport your nitro-glycerine that concussion or percussion, internal or external, shall become physically impossible, and so that no violent or extreme change of temperature, above or *below* a fixed mean, shall occur; effect that, and future danger or "accident" will, to a great extent, vanish.

It seems but little generally known that the wonderful, and even yet little understood rapid inversion of chemical forces called explosion, tends to propagate itself, by mere shock perhaps, from one isolated mass to another. The facts observed as to the successive blowing up of more or less distant buildings in powder mills, when one only has been first exploded, shows that this is true even of gunpowder, an agent which is with great difficulty, and only under certain circumstances, caused to explode by percussion, as Faraday long ago showed. But it is eminently true of fulminates properly so called, of which nitro-glycerine is one; for though explodable either by sufficient ignition or heating, it is far more readily so by any violent shock, or by a blow from a hard body, or from even a gas evolved at great velocity, as from a percussion cap.

When Mr. Hennel, the operative chemist at Apothecaries Hall, London, was blown to atoms many years ago by the explosion of a large copper dishful of fulminate of mercury, holding several pounds, beside which at a distance of several feet he was standing, the explosion of the whole appeared to have been induced by the slight but sharp impulse given through the air, by the explosion of a grain or two of the fulminate which he incautiously took out and exploded by a blow of a hammer to judge of the quality of the mass itself.

Mere subdivision of nitro-glycerine into small parcels—these being placed tolerably adjacent or in the same building—will be nugatory as any safeguard that one portion

only may explode and leave the others untouched.

Roughly we may say that unless the distance between the stored separate masses be such, or the interposed divisions—such as heavy walls, vault arches, or the like—be so massive that the shock or sound of the explosion of one mass shall be imperceptible at any one of the others, mere subdivision can afford no certain security that when one goes all shall go off in succession. But there is another circumstance to be taken into account—the effects. Now, the leveling agency and life-destroying power of nitro-glycerine are so great, and so much in excess of gunpowder, that subdivision ought to be insisted on, and we hold it that the law should provide:

1. That no nitro-glycerine should be stored at all, except in places not less than half a mile from any inhabited house or factory, or other usual resort of large numbers of employed persons.

2. That public stores should be provided for it, to which it should be removed from ship or railway on the night after its arrival, and only at night.

3. That not more than 500 lbs. should be stored any-where in one mass, and to that extent only in public magazines.

4. That transport through public thoroughfares should only be done on license given, after written notice to a public officer (probably of the customs or excise), and then accompanied by a subordinate appointed by that officer.

5. That all private consumers should be obliged to provide magazines, to the approval of a recognized authority; and that these be on the same principle of distant subdivision and position as to human habitations, etc., as the public magazines; and that the maximum stock in any one mass should not exceed such quantity less than 500 lbs., as such authority should sanction.

These regulations would really impose no serious burden or restriction to use, and, so far, would be pretty effectual.

There remains, then, the mode of package and transport; and here there is immense present recklessness, and room for an immense improvement. Soldered zinc or tin-plate or galvanized iron bung-stopped cans are about as dangerous as any vessels can be. Leakage can scarcely be avoided at the bung—a screwed stopper is still worse—the chance of leakage is great, and a fragment of flint, or grit, or glass, or of any hard body, in extracting or replacing it, may cause explosion. The soldering is often staunch at first, simply by reason of a film of *rosin* at an imperfect place; and when this dissolves or is rubbed away leakage occurs; and if some of the leaked liquid be exploded, though outside and some feet, perhaps, from the can, the whole may explode. But there is a further and more insidious cause of danger. Many such cans have bits of loose solder accidentally included in them, or bits that may become loose. These are necessarily tail-like bits, with sharp points and of angular forms. These, if shaken about in the can, may induce explosion, as may a bit of wire, or an iron prong or broken corkscrew, or any sharp and hard solid if dropped into the can, and afterwards shaken about in it. In fact, just as a needle thrust into a glass of still soda-water or a few angular crumbs thrown into a glass of dead champagne will re-establish effervescence, so is the instability of already unstable chemical compounds increased, and if explosive, their tendency to explode. Even rough points, or lines, or seams, and far more, sharp corners or re-entering angles in the inside of vessels have the same effect, of which many remarkable examples have been noticed and recorded, both as regards combination and decomposition, by Chevreul, Becquerel, Mallet, and others. But we must be brief. We say, therefore, that in place of these cans the only vessels permitted for transport and storage of nitro-glycerine should be strong ellipsoidal metallic bottles, something the shape of a soda water bottle but of larger diameter in proportion to length, and each made out of one sheet of metal without solder or seam, by the method of hydraulic pressure in suitable moulds, which was exhibited, in 1867, in the French department, and examples of its marvelous facility and adaptability to any form or size there shown.

These vessels should be strong enough to resist dinges or dents by any moderate blow or by being let fall from a man's hands, and should be perfectly smooth within. The neck should be wide enough to enable the whole inside to be examined by the aid of a properly projected and powerful illumination, and it should be closed neither by bung nor ground valve, nor screw cap, nor by anything capable of producing rubbing, friction or catching up grit, or requiring force and iron instruments to extract—but instead by a flat plate having a ring of gutta

percha or cork, or other more suitable and slightly compressible material inserted flush in a circular sunk race, and made to bear against the flat edge of the neck of the vessel. This plate or valve should be pressed tight into place, and held there by a screw bearing upon its outer surface, and passing through a Ω-shaped bridge, hooked on to two lugs, formed outside the neck of the bottle. Each such bottle should be packed into a sheet iron cylindrical canister with a cap, and at least 2-in. or 3-in. of dry elastic sawdust intervening all round it, and each such packed canister should be enveloped always in a thick mat of "gunny bagging," or other cheap elastic material.

We cannot extend here further, though much more remains that we should like to add. However, were even the precautions, which we have here rapidly sketched, taken, and zealously, and not in laziness and official sham, but really carried out, we venture to affirm that a considerably increased length of time would be found to elapse before the next blow-up of nitro-glycerine should occur; and whenever it should we would hope that the coroner's jury verdict would not be, as at Carnarvon, one of "accidental death."

SHRAPNELL *v.* SEGMENT SHELL.

From the London "Times."

There are three distinct parties in this controversy. First, the out-and-out Segmentite, who considers shrapnel a thing of the past, and has not the slightest faith in it either as a shell or a shot; second, the rabid Shrapnelite, who looks upon his favorite projectile with the fluttering affection with which a hen regards her one chicken; and considers that segment shell violates every condition of scientific and practical gunnery, and is utterly inadmissible in consequence; third, the dispassionate party, who are platonic enough to view the contest with unruffled equanimity, and whose chief object is to get the best thing they can for the service, irrespective of the fact that it is the invention of Boxer or Armstrong. Let us see, now, what these several cliques have to say for themselves.

The Segmentite usually affects to be eminently practical; he disbelieves in the efficient boring of time fuses in action, ridicules the firing of such projectiles under most of the circumstances met with in actual war, and calls the rifled shrapnel a wooden-headed piece of complication. It is absurd, he urges, to suppose that future battles will be fought over ground selected expressly to develop the merits of shrapnel fire. Troops will be more or less protected, the soldier will instinctively seek cover, and the very key of the position on many a battle field may be a rude house and garden, with a few hastily thrown up entrenchments, against which the fire of shrapnel would be entirely thrown away. What would be the position of a general under such circumstances if provided with a shrapnel alone? Must he wait for his siege train before he could attack a farm-house? With what projectile are we to attack stockades, abattis, houses, villages, woods, field earthworks, and war material such as guns, carriages, and wagons? Are horse artillery when acting with cavalry in pursuit of an enemy to be obliged to bore and fix fuses in the hurry and excitement of action, when time is of the greatest possible consequence? Is the No. 1 supposed to ride with his pockets full of fuses, and the gimlet in his mouth? Suppose the man with the bradawl is killed, who is then to "look for the needle in the bundle of straw?" The segment shell can be fitted with a concussion fuse and carried into action ready loaded. No boring and fixing of fuses is necessary. The gun may be served as quickly as with shot; the burst on graze facilitates the estimation of distance, and a few turns of the elevating screw is all that is required. Look at the simplification of drill under these circumstances. The soldier has nothing to look for but the cartridge and shot; he may be the veriest tyro, and still be an efficient gunner. The use of time fuses, on the contrary, necessitates careful drilling. A man whose fingers are all thumbs from the cold of Canada would make a sorry exhibition in boring a time fuse, particularly if he had only been partially instructed, and in case of war there is little or no time in which to instruct the recruits sent out hurriedly to replace casualties in the ranks. Such we may suppose to be the chief arguments advanced by the out-and-out Segmentite.

To him the rabid Shrapnelite replies: The shrapnel shell is constructed on true principles, which cannot be said for the segment. Such a fire is more independent of a correct knowledge of range and configuration of ground than any other. It is manifest that it matters not to the shrapnel shell, bursting as it does in the air, whether the ground be hard or soft, smooth or broken,

undulating or flat. The action of the concussion segment depends, on the contrary, on the nature of the particular spot struck. If that be the side of a hill, the projectile enters the ground, and the effect is merely a shower of earth; if it be a soft morass, the shot buries itself in the spongy ground. To obtain good results from segments it is necessary to burst the shell close to the object, and there is a greater chance or probability of oversight in the correct elevation of the gun than there is in the true boring of a fuse where a certain limit of error is admissible. The velocity, again, of the segments will be materially diminished by the shell striking the ground, and the comparative effects will be less than in the case of a projectile bursting in the air unchecked. The spherical bullets of the shrapnel meet with much less resistance from the air than the irregularly formed segments. The fire of shrapnel is much more formidable than segment against troops in the open field, either as skirmishers or in line, and although segment shell may under certain circumstances have a seeming advantage, the result is generally to be attributed to accident. Troops under cover must be dislodged by special means; common shells must be "lobbed" so as to render their retreats untenable. All such defenses as pahs, stockades, abattis, earthworks, etc., must be attacked by common in conjunction with shrapnel shell. The boring and fixing of fuses is a mere matter of drill; in the old smooth-bore days no difficulty was experienced, and there is no evidence to prove that the race of gunners has degenerated, or that we have now less of the coolness and intrepidity for which the regiment has ever been justly celebrated. This soldier-like quality is assuredly present amongst us to-day as formerly. There is no reason why, with an efficient system of drill, shrapnel shell should not be fired just as quickly as shot. It is an error to suppose that heavy infantry or cavalry columns will be massed on future battle-fields; on the contrary, the troops are more likely to be moved in open order, and with an extended formation, to enable them to use with greater effect the improved weapons of the present day. We shall have shallow formations combined with a rapid system of light infantry drill. Against such an order of battle the fire of shrapnel will tell with deadly effect. On the other hand, if concussion fuses are found to be most effective against troops in column, there is nothing to prevent their use with shrapnel shell.

Having heard the arguments on both sides, the moderate party may be supposed to draw the following conclusions: Shrapnel shell, when served with deliberation, is, doubtless more effective than segment shell under certain conditions. On the other hand, the segment shell fitted with a concussion fuse is always ready to hand, and is certainly more simple and decidedly cheaper than shrapnel. Probably two segment shells, with a simple concussion fuse, could be bought at the price of one shrapnel. Again, segment shells, when fired with concussion fuses, have proved themselves very formidable projectiles against abattis, guns, stockades, and troops under the cover of low walls and breastworks. It is very improbable that the leaden bullets of the shrapnel would have much effect in cutting to pieces the wheels of gun carriages or the struts of a stockade. We have fired segment shells with concussion fuses in real warfare, and all the officers who have used them, or witnessed their use, speak most highly in their praise. It is notorious that both the Russians and Prussians look on shrapnel shells with disfavor; even the Austrians, who use a pattern almost identical with our own, are said to have considerably reduced the proportion of shrapnel carried by their field batteries. Now, this course has been adopted, not from the results of a fire against inanimate two-inch wooden planks, but against warm flesh and blood; and, although we may have our insular prejudices on following or regarding the opinion of foreigners, we should proceed with due caution and do nothing hastily. The Boxer shrapnel is an admirable projectile, and we are justly proud of the inventor, but will it satisfy all the requirements of service? If we adopt an exclusive employment of shrapnel, are we right, and all the rest of the world wrong? On the other hand, suppose both are right, would it not be advisable to have some of both projectiles? No doubt by adopting this course we shall please neither the thorough going Segmentite nor the rabid Sprapnelite; but what then? We have no personal interest in either Sir Wm. Armstrong or Colonel Boxer beyond a sincere admiration for the talents of both. Our object is to adopt the best projectile we can for the service, irrespective of its maker. Which would it be best to have—shrapnel, common shell and case; or shrapnel, segment shell and case?

LONDON STREET RAILWAYS.

From a paper before the Inventors Institute by Mr. Thos. Measam, A. I. C. E.

After mentioning the successful attempts of Mr. Train and others to establish street railways in London, and describing the routes of the three roads now projected, in all 6½ miles of double and 6⅜ miles of single line, the author says: The early tramways appear to have been constructed in the following manner: Cross sleepers of timber, some 6 ft. long, and varying from 6 in. to 8 in. square, were fastened, by tree-nails or other means, 4 ft. apart. Upon these planks two wrought-iron angle-plates, about 4 in. wide, and 1¼ in. thick, were firmly secured. This construction evidently affords all the mechanical advantages that are derived from tramways of more recent date. The tramways laid down by Mr. Train, in 1861, in London and elsewhere, and which were similar in construction to the most improved trams then in use, and which continue largely to be in use in some of the principal cities of the United States, consisted of two wrought-iron plates, each 5 in. wide, weighing 50 lbs. to the yard, and bent at near the center to a depth of ¾ in. below the general level of the road. These plates were fixed to longitudinal timbers, embedded on concrete, and the gauge of the line was that of ordinary railways—4 ft. 8½ in. These trams proved dangerous and obstructive. The construction of the improved tramways now proposed is as follows: For single lines of tramway, two flat wrought-iron plates, each 3½ in. wide, weighing 40 lbs. to the yard, with an indented channel 1⅛ in. wide, and ⅜ in. deep, placed on one side of the center line of the plates, are to be fixed by bolts, or otherwise, to longitudinal timbers of the width of the plates placed at such distances apart as to give 4 ft. 8½ in. for the gauge of the line. The timbers are to be embedded in concrete 9 in. deep, and are to be of 6 in. or 9 in. in depth, according to the size of the pitching used for the roadway. Tie-bars of thin wrought-iron, connecting the longitudinal timbers, are proposed to be placed at intervals of 4 ft. The space between and on either side of the tramways is to be paved with granite pitching. In the case of double lines, the intermediate way between the trams is to be 4 ft. wide, and the whole space from 11 in. on either side the outside rails, equal to 17 ft. is to be paved the entire width. In other respects the double line is of identical construction with the single tramway. The estimated cost for the paved single tramway is £6,000 per mile, and for the double tramway £12,500 per mile. Another form of rail (known as the "crescent rail") has been used for tramways to a limited extent, but it is considered much inferior to the rail before described, and is not likely to be much adopted. It consists of a curved plate of wrought-iron about 2½ in. wide, and weighs 24 lbs. to the yard.—The grooves for the flanges of the wheels are partly formed by the granite pitching, which cannot but be considered a very imperfect contrivance. In the American system of tramways the longitudinal timbers are tied together by 4 in. planks instead of with iron bars, the planks being placed under the longitudinal timbers. In other respects the American tramways vary but little in construction from the tramway described. The rails first used were similar in form to Train's rail, and were now in a great measure superseded by the improved rail. The carriages proposed by the London tramways are to weigh 33 cwt. The length of the body of the carriage is to be 16 ft.; the width over all, 6 ft. 8 in. They are to carry fifty passengers, and are to be so constructed as to give 1 ft. greater space between the seats than is given by the omnibuses now in use. The maximum rate of fare is to be one penny per mile for distances above three miles, and 3d. is to be the least fare. The rate of traveling, including stoppages, is to be six miles per hour.

Tramways, said Mr. Measam, would doubtless give easier traveling and more commodious conveyances than are to be obtained at present, but here—excepting that the tramway companies are to maintain a portion of the public roadway over which they pass—the advantages of tramways seem to cease. It is surmised that a line of carriages passing to and fro every three or four minutes in one undeviating line, claiming priority of way, and scattering the general traffic, cannot but be productive of annoyances, to say nothing of the obstacles which the rails may cause. It is much to be doubted, Mr. Measam thought, whether all the disadvantages resulting from Train's tramway were alone due to the rail used by him—which, it must be remembered, had been in use for some time in the United States—or whether they were not, in a great measure, inseparable from the working of the tramways on a roadway of mixed traffic. Further objections

to the introduction of tramways start up in the form of difficulties put in the way of connecting houses in their line of route with the gas and water mains and with the sewers. But the chief objection to street tramways as proposed to be introduced seems to be, that individuals acquire privileges and rights in the public highways not possessed by the community at large, and that the public property is appropriated for the use and trading purposes of private speculators. Although some strong measure was necessary to destroy the existing monopoly in metropolitan street passenger conveyance, to bring this about by so great an interference with the public rights as the permitting of individuals to construct permanent works on the public highways, is a remedy likely to produce worse evils than those it is intended to remove.

There is another consideration in favor of tramways, however, and that is the reduction of friction resulting from their use. On a good paved road the force of traction is about 24 lbs. for every ton weight of carriage, including, of course, the load. On a tramway it may be taken at 8 lbs. per ton, giving a mechanical advantage to the tramway on level surfaces of 3 to 1. On inclines the advantage rapidly decreases, and on a gradient of 1 in 26 (which it is believed, is the steepest incline there is on the proposed metropolitan tramways) the difference of the force of traction on a tramway as compared with a paved road is only as 117 to 100. Practically, it may be considered that a horse on a tramway will do the work of two horses on an ordinary road. The practical advantage of street tramways, therefore, seems to resolve itself into the fact that the same amount of traffic can be conducted at one half the expenditure of horse power necessary on an ordinary road. This advantage is purchased at the cost of the construction of the tramways, and the maintenance of a large portion of the highways. The estimated cost of the tramway from Whitechapel to Stratford is £45,000, excluding coach-houses, stabling, etc. The annual expense of maintaining the highway the company is bound to keep in repair, assuming the cost at one shilling per yard, would be about £1,600. On the other hand, assuming 120 horses to be the number required for conducting the traffic, there would be a set-off against the above specified expenditure of the value of this number of horses. Considering that commodious carriages are not necessarily restricted to the railway system, the omnibus proprietors need not much fear the rivalry of the tramway companies. That tramways are the best suited for omnibus traffic none but omnibus proprietors would deny, and if a portion of the public roads is to be set aside for omnibus traffic, no better mode of conducting it than by tramways could be devised; but considering the different kinds and the large amount of traffic that has to be accommodated, and the various uses to which the public roads are necessarily applied, Mr. Measam considered it would be more generally advantageous to restrict the construction of tramways, as has hitherto been the rule, to such roads as their promoters have an exclusive right to use.

In the discussion which followed the reading of the paper, the chairman said that with regard to the metropolis, tramways were unsuited to the wants of the traffic at large, although they might advantageously be adopted in such wide thoroughfares as were to be found on the Surrey side. In Cheapside trams would be out of the question. He was practically acquainted with the working of Train's tramway, however, and he was bound to say that there was not the slightest ground for saying that any accident was caused by the projection ($\frac{3}{4}$ of an inch) of his rails. There was no such thing as the breaking of good axles by going over the rails, but four or five people were specially paid to take broken-down carriages with bad axles and bad springs, and drive them over and over the rails until they inevitably had a "smash." There was no mechanical difficulty in the way of making tramways succeed, but the Legislature would (the chairman thought) be better advised if they gave powers to make increased thoroughfare accommodation rather than to construct tramways. Mr. G. W. Reid, from America, said that on that continent there were 10,000 or 15,000 miles of tramway at the present time. In Boston, a city built on exactly the same model as London, with narrow winding streets, tramways were laid in all the principal streets, and worked with perfect success in thoroughfares not wider than our own misnamed Broad-street City, and there was not one street in Boston in which the trams were laid down wider than Cheapside. Where the streets ran parallel and contiguous to each other, the "up" line was carried along one street, and the "down" line along another. Mr. Greaves, as engineer to one of

the schemes just sanctioned by the select committee, adverted to the excessive cost entailed in getting private bills for public works through Parliament, and said that (seeing that tramways were undoubtedly public boons) he did not see why vestries and local boards should not lay down these trams. They had the power to pave the roads in what manner they pleased; then why not make a portion of the paving to consist of iron trams with grooves in them?

STEAM ENGINE PERFORMANCE.

Messrs. Farey and Donkin have recently made some remarkably thorough and comprehensive experiments in this direction, which are quoted and discussed in the London papers. The following are the particulars and the comments of "Engineering":

Experiments by Mr. Farey and Mr. B. Donkin, jun., upon a Double-Cylinder Jacketed Condensing-beam Steam Engine of 30-horse power nominal, constructed by Messrs. B. Donkin and Co., Bermondsey, London.

Dimensions of engine.	Diameter of cylinders 24 in. and 13 3/16 in., having strokes respectively 4 ft. 6 in. and 3 ft. 3⅜ in.	Stroke of crank 4 ft. 6 in.
Indicated horse-power, taken with four indicators, diagram taken every half hour, work very constant.....		46.21 HP.
Pressure of steam in boiler house by mercurial gauge, taken every half hour, kept very constant. mean...		40.9 lbs.
Pressure of steam in engine house taken every half hour, mean.....		40¼ lbs.
Duration of experiment.....		10 hours.
Revolutions of engine per minute, by counter, mean speed.....		32.48 rev.
Vacuum in condenser by mercurial gauge, mean.....		27 in.
Condensing water. The temperature and quantity were taken constantly by a self-acting recording photographic apparatus, as described in "Engineering," July 17, 1868. Temperature.	Going in from a deep artesian well quite constant	53°
	Coming out, taken photographically mean.	89.54°
	Degrees of heat put into condensing water or rise.	36.54°
Quantity.	Quantity of water per min., measured over a tumbling bay 6 in. wide, height recorded photographically,	408.32 lbs.
Pound-degrees.	Lb.-degrees per min., or units of heat 408.32 lbs. × 36.54°	14,920 lbs.
	Lb.-degrees per min. per indicated horse-power 14,920 / 46.21	322.87 lbs.
Water from Steam jackets. Temperature.	Taken every quarter hour, hour, mean.....	207°
Quantity (from a steam trap).	Total pounds accurately weighed.....	1,783¼ lbs.
	Pounds per minute.....	2.97 lbs.
Feed water taken from Water Company. Temperature.	Taken every ten minutes, mean.	74½°
Quantity.	Total water evaporated in pounds	10,404¼ lbs.
	Pounds per hour.....	1,040.4 lbs.
	Pounds per minute	17.34 lbs.

Description of boiler; vertical tubular.

Total quantity of coals burnt, accurately weighed (quality of coals—Welsh, but very inferior, great deal of dirt, shales, cinders, and clinkers	1,204 lbs.
Pounds water per pound coal burnt, or efficiency of boiler with this coal..	8.72 lbs.
Pounds coal per I.HP. per hour.....	2.61 lbs.
Pounds water evaporated from temperature of 74½° per I.HP. per hour	22.51 lbs.
Expansion with steam cut-off at about 7/16th stroke in small cylinder, allowing for passages and clearances, about.....	11 to 1
Number of indicator diagrams taken, four always taken simultaneously, two at top and two at bottom of the two cylinders.	84
Temperature of outer air, fine day	67°
Temperature of steam-engine house, mean.	76°
Height of barometer	30 in.

Tallowed cylinders twice, 1¼ pints tallow used, also 1 pint of oil for all other parts.

This same steam engine indicated, when running empty, including cold water pump, was found to take 3¼ indicated horse-power.

Other experiments on this engine gave a result of about 300 pound-degrees at ¼th cut-off in the high pressure cylinder, instead of 323 pound-degrees at 7/16ths.

In this experiment the vertical boiler evaporated only 8.72 lbs. water per pound of inferior Welsh coal, but in other experiments on the evaporative power of this boiler, when using a better quality of Welsh coal, and evaporating double the quantity of water in the same time, the result was 10.01 *lbs. water per pound coal*, with feed water at 61° temperature. Had this been the case in the above experiment, the quantity of coal consumed would have been 2¼ *lbs. of coal per indicated horse power per hour*.

The trial was conducted throughout with great care, four engineers being employed to take indicator diagrams simultaneously from the upper and lower ends of the two cylinders every half hour; while a fifth en-

gineer checked the registration of the photographic apparatus by noting every quarter of the hour the rate of flow and temperature of the water from the hot well. A sixth engineer observed the boiler pressure, and kept account of the weight of coal used; while a seventh measured the quantity and temperature of the feed-water, and an eighth recorded the quantity and temperature of the water drawn from the steam jacket.

The results above recorded are of great interest, and by analyzing them we shall be enabled to show approximately the manner in which the heat generated by the combustion of the fuel is disposed of. In the first place we may assume that, as the coal was of inferior quality, it would not, on an average, be capable of yielding more than about 13,500 units or pound-degrees of heat per pound consumed; and as the rate of consumption was almost exactly 2 lbs. per min., we may fairly take 27,000 units of heat per minute as the gross quantity of heat theoretically available. The quantity of water evaporated per minute is given as 17.34 lbs., this water being converted into steam at a pressure of 40.9 lbs. above the atmosphere. The total heat of steam at this pressure is 1,201.6, or, say, 1,201½°, and as the feed-water was supplied at a temperature of 74½°, each pound of water in being converted into steam would absorb 1,201½–74½ =1,127 units of heat; and the total amount of heat thus absorbed per minute would be 1,127×17.34 =19,542.18, or, say, 19,542 units. Again, if we assume 24 pounds of waste gases to be evolved from the furnace per pound of fuel burnt, and further assume that the specific heat of these gases is .24, and that they were discharged into the chimney at a temperature of 400° above that at which the air was supplied to the fire (all fair assumptions), we get 2×24×.24×400 =4,608 units as the quantity of heat carried off per minute by the waste gases. We can thus approximately account for the heat generated per minute by the combustion of the coals, as follows:

	Thermal units.
Heat absorbed by the generation of steam,	19,542
Heat carried off by waste gases.....	4,608
Heat lost by radiation, imperfect combustion, etc.....	2,850
Total	27,000

Of the 17.34 lbs. of steam produced per minute, 2.97 lbs. were condensed in the steam jacket and discharged as water at a temperature of 207°. Of the steam thus condensed in the jacket, each pound thus gave up 1,201.6° — 207° = 994.6 units of heat, and multiplying this number by 2.97 we get 2,953.962, or, say, 2,954 as the number of units of heat per minute given up by the steam jacket. The weight of steam admitted into the cylinders of the engine (supposing no condensation to have taken place on the way from the boiler) would be 17.34 — 2.97 = 14.37 lbs. per minute, and as the steam was ultimately discharged into the hot-well as water, at a temperature of 89.54°, each pound must have had abstracted from it on its way through the engine 1,201.6—89.54 = 1,112.06, or, say, 1,112 units of heat. We thus have 14.37 × 1,112 = 15,979.44, or, say, 15,979 units as the quantity of heat given out per minute by the steam during its passage through the engine, and adding to this the 2,954 units given up by the steam jacket, we have a total quantity of 18,933 units per minute to be accounted for.

It will be noticed that the quantity of heat just mentioned is less by 609 units than that absorbed in the generation of steam, this deficit being caused by the water being drawn off from the steam jacket and discharged from the hot-well at higher temperatures than it is supplied to the boiler. Thus the 2.97 lbs. of water withdrawn from the steam jacket had a temperature of 207°, or 207 — 74½ = 132½° higher than that of the feed; and 2.97 × 132.5 = 393.525, or, say, 393½ units are thus accounted for. Again, the condensed steam in the hot-well had a temperature of 89.54°, or 15.04° higher than that of the feed, and multiplying this by the weight of steam passing into the hot-well per minute, we get 15.04×14.37 = 216.1248, or, say, 216 units thus disposed of, a quantity which, added to the 393½ units above accounted for, gives 216 + 393½ = 609½ units, or half an unit more than the deficit above mentioned. The discrepancy of half unit is of course due to the decimal parts of an unit being neglected in our former calculations.

To return now to the 18,933 units of heat per minute, which have to be accounted for. In the first place, as the engine was developing 46.21 horse-power, 46.21 × 33,000 = 1,524,930 foot-pounds of work were being performed per minute, and dividing this number by 772 (Joule's equivalent), we get 1,975 as the number of pound-degrees or

units of heat transformed into work. Next, it will be seen, on reference to the report of the experiments, that 408.32 lbs. of water were discharged from the hot-well per min., and subtracting from this quantity the 14.-37 lbs., resulting from the condensation of the steam passed through the engine, we get 393.95 lbs. as the actual quantity of water which was raised in temperature 36.54°; and $393.95 \times 36.54 = 14,394.933$, or, say, 14,395 units of heat per minute are thus accounted for. We may thus say that the 18,933 units of heat per minute were disposed of as follows:

	Thermal units.
Converted into work	1,975
Imparted to condensing water	14,395
Lost by radiation, etc	2,563
Total	18,933

The summary is a very striking one. It shows that even in an engine of thoroughly good design and workmanship, working with what is considered a very low consumption of fuel, but about 10.4 per cent of the total amount of heat parted with by the steam is converted into useful work, whilst rather over 76 per cent is imparted to the condensing water, and about 13½ per cent lost from radiation and other causes.

TEST OF AGRICULTURAL STEAM ENGINES.

A correspondent of "Engineering," under the head of "Steam Cultivation and R. A. S. E. Prizes," writes as follows:

That steam cultivation is approaching success, no one who has watched the various phases it has passed through can doubt, but up to the present moment it can scarcely be called triumphant, and the reason seems to me simple. Horse work upon a farm consists not merely of ploughing and cultivating, but also of a vast amount of cartage in drawing out manure, bringing home crops, taking produce to market, and bringing back lime and other artificial manures from the railway station. Now until a steam engine is able to do the heavy part of this work, in addition to ploughing, none but large and wealthy farmers or rich amateurs will be able to enjoy the luxury and the benefit of a steam plough. For a steam engine to be a thoroughly economical farm implement, it must, in fact, be able to exercise economically three distinct functions.

1. It must be suitable to drive thrashing and other farm machinery.

2. It must be able to plow and cultivate efficiently.

3. It must be a good and handy traction engine, able to draw heavy weights along the roads, and to haul out manure during dry and frosty weather, to suitable central positions on the farm.

But up to the present time we have no engine that will perform these three things economically. We have engines that will do two of them, but none that will do all three. Aveling and Porter make a very efficient although heavy traction engine, which will also drive farm machinery, but they are non-plussed when they come to ploughing. Fowler and Co., Garrett and Sons, and Howard & Co., make good enough ploughing engines, which will also drive ordinary farm machinery, but they are beaten when they attempt to work as economical traction engines.

The Royal Agricultural Society of England must move onwards, by offering a premium for an engine which shall subserve all three purposes. But unless the conditions on which the award is to be made be very carefully considered, the object will not be attained.

It must be evident to any one that the prime cost of the machinery is a very material element, but unless some data are given to fix the cost, an unscrupulous maker may call his engine such a power and at such a price, and when he comes to supply others, may give a totally different machine. Heretofore it has been the custom to talk of engines as being so many horse power, but when one comes to ask what this horse power is gauged by, we are generally told that the size of the cylinder is the criterion. Now there could not be a more fallacious guide. An 11-in. cylinder is usually called a 12-horse engine, and by the best makers that size of cylinder will be put on to a boiler having 240 square ft. of heating surface, and will be called a 12-horse engine, for the best makers allow about 20 square feet of heating surface for each nominal horse power. Again an 8-in. cylinder is usually called a 6-horse engine, being about half the area of the 11-in. cylinder, and if both cylinders work at the same speed, no doubt the large cylinder will do about twice as much work as the small one. But suppose we put an 8-in. cylinder on to a 12-horse boiler (240 square ft. of heat-

ing surface), and drive it *twice as fast, the small cylinder will then do rather more work than the large cylinder.* Would it not be folly, then, to call that engine a 6-horse engine, simply because we had changed the cylinder? But it may be said, why not drive the large cylinder fast also? The reply is very simple: the boiler would be unable to supply it with steam because a certain area of heating surface will only evaporate a certain quantity of water economically.

It is plain, then, that the heating surface in the boiler is the true test of the power of an engine, and if it be agreed by all that 20 square ft. of heating surface shall be denominated 1-horse power, then the engineer who can develop the greatest amount of *useful effect* out of that extent of heating surface, is the most successful engineer; and the man who can produce an engine at *the lowest prime cost in proportion to the work done* is the cheapest engineer. But here another element drops in. If an engineer is reckless of the quantity of coal that he uses, he can so dispose his heating surface as to make it evaporate much more than it would do if it were arranged to absorb the principal portion of the heat developed by the combustion of the coal. Therefore, the quantity of coal used in proportion to the work done should also enter into the calculation, for coal is an expensive article. The quantity of water, too, is a matter of great moment. 1 lb. of coal well managed will evaporate about 10 lbs. of water, and when an engine is working as a traction engine far from home, or as a ploughing engine on a steep and dry hill-side, it is quite possible that to supply it in such situations with water might actually be as expensive as to supply it with coal. If, then, one engine will work for a whole day with, say, 400 gallons of water, and another engine doing the same amount of work requires 1,000 gallons, surely that ought to be considered in awarding a prize.

Weight, too, is another element. A very heavy engine is difficult to move about over farm roads and along soft headlands; and if it breaks through the skin of a cross country road, it will often involve its owner in very unpleasant disputes.

The extreme width, too, of the engine ought to be limited. Few farm-gates are more than 8½ ft. in the clear. Now Messrs. Howard's engine, I believe, is 8 ft. 9 in. wide, and to pass such an implement through an ordinary farm-gate is impossible. Messrs. Aveling and Porter's engines are, I believe, 8 ft. 2 in. wide, and to guide those through an ordinary farm-gate is plainly a work of difficulty. Such wide machines, too, are very awkward on country roads, where they have to pass wagons, carts and carriages. The R. A. S. E. might easily name a maximum width, which no manufacturer intending to compete should exceed; 7 ft. seems to me ample to cover everything, and if a manufacturer cannot produce a good engine not exceeding that width, he had better give way and allow men of greater ingenuity to take his place.

It is pretty plain, too, that any engine to be useful for ploughing or traction purposes should be able to go up and down steep inclines without uncovering any portion of the heating surface that is exposed to severe heat, for it is extremely dangerous. An engine, when ploughing, may have, for many days to be working up or down an incline of 1 in 8, or even steeper. Now, if an engine be so constructed that with the ordinary supply of water its firebox would be uncovered upon such an incline, it is plainly unfit for its work.

It appears to me, then, that the Royal Agricultural Society might lay down as a *sine quâ non:*

1. That each engine intending to compete shall be capable of working as a ploughing engine, as a traction engine, and as an engine for driving ordinary farm machinery.

2. That no engine shall compete if, when working up or down an incline of 1 in 8, it uncovers any portion of its firebox to a less depth than 4 in. of water at the shallowest point.

3. That no engine shall compete if it is wider at any point than 7 ft., and to prevent this width being only temporarily diminished by decreasing the breadth of the wheels, no engine should compete if each driving wheel of the engine be less than 1½ in. broad for each ton weight of the engine, when loaded with 10 hours' coal and 2 hours' water. That is to say, a 10-ton engine must have 15-in. driving wheels at the least.

If these matters were once agreed upon, then it seems to me that the goodness of each engine in each particular department, if I may use the word, could be determined by allotting to it so many points, and whichever engine gained the most points would gain the first prize, just as in a competitive examination for the Indian Civil Service.

In making the actual trials, I think that two will be enough, for if an engine works cheaply and well as a ploughing engine, and also as a traction engine, we may safely assume it will be an economical engine for driving ordinary farm machinery. But in trying an engine with its cultivating machinery, it is a question whether it should be tried both with a plough and with a cultivator, or only with one of them. It seems to me that the plough is the implement most thoroughly understood by farmers, and is, therefore, the fairest implement by which to test the success of steam cultivation; for if it works the plough well, we may safely assume it will work the cultivator equally well.

In trying the engines as ploughing engines, each should have a plot of three acres given to it, the choice of plots being determined by lot. Then the engines and the ploughs being all in their places, the fires should be thoroughly drawn at a given signal, and the valve opened to bring down the steam to the pressure of the atmosphere. When this was done, and the judges had satisfied themselves that the fires were thoroughly drawn, and the steam pressure run down to that of the atmosphere (a watchman being placed at each engine) accurate account should be taken of the height of water in each boiler, and the quantity of water in each tender, a certain weight of coal, and a small quantity of wood and shavings should be given to each engine, and at a given signal the fires should be lighted, and the trials should commence, time being duly marked. As each engine finished its task, time could be again taken, and the results deduced as follows:

1. Divide the weight of soil moved in an hour by the square ft. of heating surface in the boiler.

2. Divide the weight of soil moved in an hour by the gallons of water used.

3. Divide the weight of soil moved in an hour by the number of men employed; two boys, provided they are really doing boys' work, to count as one man.

4. Divide the weight of soil moved in an hour by the lbs. of coal used.

5. Divide the weight of soil moved in an hour by the cost of the apparatus

Each of these things to count one point to the winner, and whichever engine gains most to have the first prize, and the next the second prize. But if any engine gains four out of the five points, that engine to get a gold medal and the first prize, and the next engine to get only a third prize. Or if any engine gains all five points, such engine to get a gold medal and sole prize, no other prize being awarded.

In trying the engines as traction engines, I should be inclined to make them start cold and draw a load over a given piece of ground, up a steep incline, say, 1 in 12. Whichever engine first brought its steam up to a given pressure should gain *one point*, and after each engine had drawn its load (of such weight as its owner might fix upon) along the given distance I would decide the trial as follows:

1. Divide the net load by the time, the winner to gain *one point*.

2. Divide the net load by the square ft. of heating surface, the winner to gain *one point*.

3. Divide the net load by the lbs. of coal used, the winner to gain *two points*.

4. Divide the net load by the gallons of water consumed, the winner to gain *two points*.

5. Divide the net load by the weight of the engine, the winner to gain *two points*.

6. Divide the net load by the cost of the apparatus, engine, and tracks, the winner to gain *two points*.

This makes eleven points in all, and if any engine should gain the whole it should receive a gold medal and sole prize, or if any engine should gain ten out of the eleven, that engine to have a gold medal and the first prize, and the next engine a third prize only. But if no engine gained so many as ten points, then the engine which gains most to have the first prize, and the next highest to have a second prize.

To prevent disputes as to what should be considered the net load, it should be arranged that the total load drawn by the engine, *exclusive of its own weight*, should be considered the net load, for if you attempt to deduct also the weight of the truck which carries the load, trucks would be used in trial far too light for practical farm work, and our object is to get not a racing engine, but one suitable for ordinary farm work.

As to pressure, it has been the custom heretofore to limit this to 50 lbs. above the atmosphere, which seems to me an unreasonable limit. When we have locomotives working at 150 lbs. and 180 lbs., why should a farm engine be limited to 50 lbs? As far as danger is concerned, 50 lbs. is quite as dangerous as 180 lbs., for every good engi-

neer makes his boiler in proportion to the strain. At all events, a pressure of nine atmospheres, or, say, 120 lbs. on the square in. above the atmosphere, might be recognized; but each competitor might be called upon to declare the dimensions and substance of the various parts of his boiler, and the species of iron used, and if by calculation the breaking strain is found to be less than six times the maximum declared working pressure, then let the engine be disqualified.

If engineering and agricultural newspapers, too, would take up this matter and ventilate it, we might hope to see some proposal made for the trials in 1870, which would stimulate fresh engineering talent to enter the agricultural arena. A good manufacturer of railway locomotives would be a formidable competitor to all existing agricultural engineers.

THE BLAST FURNACES AT MIDDLESBOROUGH.

From the "Mining Journal."

There are now fifty-two blast-furnaces in operation in the immediate neighborhood of Middlesborough, besides ten more in course of building; there are about nine more of small dimensions, 45 ft. high, which are dormant, and are not intended to be again used. Besides these there are in the Tyne, Durham, and Whitby districts, thirty-eight furnaces in blast, two building, and sixteen not in use, giving a total of one hundred and eighteen blast-furnaces in the north-eastern district, either at work, or will shortly be available for the production of pig-iron. Of the fifty-two furnaces in the neighborhood of Middlesborough, their height varies from 60 to 85 ft., and their diameter is proportionately large. As an instance of economical management in the production of pig-iron, the blast-furnaces at Eston Junction, worked by Bolckow, Vaughan, and Co., may be cited as having adopted the latest mechanical appliances calculated to economize labor and reduce the cost of production. There are five furnaces at Eston Junction, 85 ft. high; the make of each averages about 350 tons of iron per week; one occasionally makes upwards of 400 tons per week. Hot-blast is used in every furnace in the district. There are five kilns for calcining the ore. One kiln will supply ore sufficient for one furnace. Each kiln is 21 ft. in diameter, 45 ft. high, having a circular frame-work of ½-in. iron plates, and 18-in. lining of fire-brick inside; these are of sufficient strength to carry a locomotive road on the top of them. One ton of coal is required to calcine 40 tons of ironstone. The calcined ironstone falls direct into the barrows from the bottom of the kilns, on raising the sluices placed for stopping the outlets, so that the labor of filling with shovels is saved. Behind the kilns are erected the gantry, about 45 ft. high, where the hoppers for storing coke are made. There are two hoppers, holding 600 tons each. The coke is let out as required by sluices, made at different parts on the underside of the hoppers, and runs direct into the barrows. A good deal of coke is thrown loose besides into stock, but it is no doubt more economical to stock it in hoppers only. The limestone is obtained at Forcett, and is tipped from the same gantry into stock, from whence it is taken to be broken by hand labor; this could be done to advantage by machinery. The calcined ore, coke, and limestone are now to be raised to the top of the furnaces; this is effected by water-balance machinery. There are two lifts for the five furnaces. Water is forced up to a tank at the top of each lift. There are two carriages for each lift ascending and descending, the cistern in the descending carriage being filled with water to raise the ore, coke, etc., in the ascending one. This is the usual method of lifting materials in this district, but Sir W. Armstrong's hydraulic machinery is in operation at the Clarence Works. Compressed air is used at Linthorpe and Tees Side furnaces, and a steam-engine and inclined plane are used at Acklam furnaces.

The blast-engines in the Middlesborough district are of various forms; there are several of the beam, connecting-rod, and fly-wheel type; a few of Slade's patent slide cylinders. Those lately erected are principally of uniform size and construction; they are on the inverted-cylinder principle, are supported on cast-iron framework, and occupy a small space. Steam-cylinder at top 30 in., blowing-cylinder below 66 in. diameter, 4-ft. stroke; beneath this the piston-rod and connecting-rod extend to the fly-wheel shaft, on which two fly-wheels, and an eccentric work, the shaft being being on a level with the floor. These engines go from 40 to 50 strokes per minute, and one of them is capable of supplying a large furnace with blast at a moderate speed. There are small engines, usually placed in the same house with three or four blowing-engines, for

forcing water to the tanks on the engine-house and at the top of furnace lift. It should be observed that where locomotive power is not used to bring materials to the top of the calcining kilns, and coke and limestone to the gantry, this is effected sometimes by a vertical lift, where steam or compressed air is the motive power; the wagons, after being tipped or discharged, are dropped down at the opposite end of the gantry and the row of calcining kilns; as these are placed usually all in one line, with a double road on the top for the transit of the trucks from one end to the other; this is a very compact arrangement on a level surface. In a few cases these materials are raised by an inclined plane and steam-engine to the top of the gantry.

The steam-boilers used in the district are nearly all of the same type. Some of these have been 20 years in existence, at work night and day. The boilers are plain cylindrical, 70 ft. by 4½ or 5 ft., slung from five cast-iron arched girders, by three straps from each girder, attached to an angle-iron piece riveted to the boiler. The blast-furnace gas is now always used to heat these boilers, the flue being a single straight one under each boiler to the chimney-flue. In some cases the gas is sufficient to heat both the boilers and hot-blast pipes. In many of the works, however, coal is used in addition. Why this is so I am unable to explain. The blast-furnaces being closed at the mouth, the gases are brought down into large wrought-iron cylindrical tubes, lined with fire-brick. In two cases the gases are brought down to an arched culvert, made underground, and from that distributed to the various blast-stoves and boilers. The pressure of blast maintained is 3½ to 4 lbs. The temperature of blast is from 1,000° to 1,100°. A great part of the economy of these blast-furnaces is due to the high temperature of the blast, and their great height. The difference in consumption of coke is so marked as to have caused the abandonment of furnaces 50 ft. high, and erecting others in their place, 70 feet high and upwards. The large production is obtained from their great diameter. An improved boiler is used at Newport Works: it has one tube; the gas passes through this, and returns under the boiler, giving much more heating surface than that before described. The whole of the boilers in the district are covered either with bricks and mortar—an air-space intervening between that and the boiler—or they are covered in a few cases with a patent composition. Each boiler is fitted with two safety-valves, two floats, two sludgers, one float, with whistle, dial, and pointer.

The blast is heated generally in the common A-shaped pipes, but at Ormesby Works the blast is heated by Siemens' stoves; these are giving satisfactory results. The air after passing for two hours through one heated chamber is diminished in temperature at its exit only 100°, and is then transferred to another chamber. The Cargo Fleet blast-furnaces are run off every eight hours. A large furnace at Norton runs off the metal both in front and back at each cast every 12 hours. These are some of the principal features of the blast-furnace economy of this district; it is evident that large outlay is required for these immense structures, the engines, and mechanical appliances, but the result is to make the manufacture a more profitable one with the present process.

COMPOSITION OF SEWAGE.

THE LONDON SEWAGE—WHAT IT IS AND WHITHER IT GOES.

From "the Engineer."

By "sewage" is commonly understood anything that flows through a sewer. But the contents of a sewer are generally very composite in their character. Sewage absolute is comparatively extremely small. Apart from water supply, rainfall, and subsoil water, an average individual contributes to the sewers at the rate of only a little more than a quart per day, solid and fluid together. Dr. Parkes, in his standard work on "Practical Hygiene," gives the daily fœcal matter at two ounces and a half, and the urinary matter at forty ounces. In bulk this would be about 73 cubic inches. In round numbers this would amount in the course of a year to one hundred gallons, or a thousand pounds, or very nearly sixteen cubic feet. Reckoning the population of London at 3,000,000, the yearly amount of absolute sewage would be 48,000,000 cubic feet, equal to 300,000,000 gallons, or 1,339,300 tons. To this we will add in the first place, the rainfall, as distributed over the area of the metropolitan district. In his evidence before the Select Committee on the Sewage of the Metropolis in 1864, Mr. Bazalgette gave the area of the district as 116 square miles, with an average annual rainfall of twenty-

four inches. But of this quantity the same authority reckoned that a proportion ranging from one-half to two-thirds would never enter the sewers, being lost by evaporation and absorption. Accordingly the rainfall which mingles with the sewage may be estimated at ten inches per annum over the 116 square miles, or, in round numbers, 72,000,000 tons, equal to 2,580,000,000 cubic feet, or 16,125,000,000 gallons. With a population of 3,000,000, this will give for each individual an annual average of 860 cubic feet, equal to 5,375 gallons, or twenty-four tons. In the next place we come to the water supply. In 1867 the water companies supplied London with an average of 98,600,248 gallons per day, of which about 81,033,800 gallons were used for domestic purposes. A daily allowance of thirty gallons per head would be just 90,000,000 gallons for a population of 3,000,000. We may fairly take this as the quantity going into the sewers, equal, therefore, to 5,268,000,000 cubic feet, or 147,000,000 tons, being at the rate per head of 1,752 cubic feet per annum, equal to 10,950 gallons, or 49 tons, leaving the brute creation—horses, cows, donkeys, dogs, etc.—out of the reckoning. We thus form an idea as to the contents of the London sewers. The effect of the rainfall is probably under estimated. Much of the absorbed rainfall may be considerered to find its way ultimately into the sewers by percolation through the brick-work. It is also probable that the area which contributes rainfall to the London sewers is larger than the space referred to in Mr. Bazalgette's evidence.

Returning now to our figures, we observe that while each individual contributes to the contents of the London sewers at the rate of nearly 1,000 lbs. per annum (less than half a ton), this is supplemented by 24 tons of rainfall and 49 tons of water supply. Reckoned daily, these quantities become 42½ oz. of absolute sewage, 147 lbs. of rainfall, and 300 lbs. of water supply. The total yearly average per head is 73.4 tons, equal to 2,628 cubic feet, or 16,425 gallons, the daily average per head being 7.2 cubic feet, equal to 45 gallons or 450 lbs. Reckoning that an acre of water an inch deep will weigh 100 tons, the unmixed sewage of London for one year will cover a space of 10,000 acres to the depth of an inch and a-third. But the proportion of rainfall which we reckon as entering the sewers would cover an equal area to the depth of 6 ft., while the water supply would cover such an area to the depth of more than 12 ft. A man walking through the sewage would scarcely do more than wet the soles of his boots; whereas the estimated portion of the rainfall would cover his head, and the water supply would leave him 6 ft. under. If to the proportion of the rainfall we add the water supply, we find that, whereas the unmixed sewage of the year covers 10,000 acres to a depth of only an inch and a-third, the sewer rainfall and the water supply combined will cover the same space to a depth of 18 ft. Thus, in the case of London, that which is commonly called sewage has only one part in 164 composed of pure human sewage, the remainder being rainfall and water supply. So far as the yearly average exceeds seventy-three tons per head of the population, the absolute sewage may be considered as undergoing a dilution even greater than the foregoing. The discharge from the metropolitan outfall at Crossness is often considerably in excess of this quantity. In the week ending May 29th, the daily discharge at Crossness was 238,840 cubic meters, or about 238,000 tons. Taking the population of the southern area at 1,100,000, this would show more than 48 gallons per head, or at the rate of nearly 80 tons per head per annum. In that week the rainfall was 1.12 in.

So great a degree of dilution might make it appear that London sewage was a very innocent thing. But it must be remembered that absolute sewage is an extremely powerful agent. The fœcal matter of the metropolis from human sources alone is equal to more than 209 tons per day, or 76,000 tons per year; in addition to which the urinary matter amounts to 3,348 tons per day, or 1,222,000 tons per year. With all this there goes down a large amount of rubbish and detritus from the roads, as well as refuse fluid and material from manufactories. According to the present system of metropolitan drainage, the sewers discharge themselves into the river, the Metropolitan Board of Works providing that there shall only be two outfalls—one near Barking Creek, and the other at Crossness. As yet the former is not in complete operation, owing to the unfinished state of the northern low level sewer. On the south side the works came into full operation some time ago. We have, therefore, to consider the probable effect of casting the enormous mass of the London sewage into the Thames at the points in-

dicated. From the Barking to the Crossness outfall is nearly two miles in a direct line. The Thames Conservancy Board, as far back as June, 1867, complained that extensive sewage shoals were being formed in the bed of the river. The report of their engineer, Mr. S. W. Leach, showed that near the northern outfall a space of more than 40 acres, and near the southern outfall of about 120 acres of the bed of the Thames was covered by a deposit of sewage mud, having a depth in some places of fully 7 ft. "The character of the mud," says Mr. Leach, "shows clearly enough whence it has come." Dr. Letheby examined some samples of the deposit, and fully confirmed the opinion expressed by Mr. Leach. "The mud in each case," said Dr. Letheby, "was black and fœtid, and in a state of active putrefactive decomposition." When examined with a microscope, it was found to consist of "broken-up sewage matter, with the remains of myriads of animalculæ, and a large quantity of carbonate of lime in a partly crystalline state." The presence of this last-named ingredient in an unusually large proportion was cited by Dr. Letheby as evidence that the alkaline constituents of the sewage were "decomposing and precipitating the calcareous constituents of the water, and thus adding to the filth of the deposit." On the attention of the Metropolitan Board being called to these allegations, Mr. Bazalgette replied that the mud deposits in the Thames, over a range of about two and three-quarter miles in the vicinity of the outfalls, had in certain places undergone an increase of 983,000 cubic yards between the years 1864 and 1867; but in certain other places along this range of the river there had been a decrease in the mud deposits to the extent of about 923,000 cubic yards, leaving the net increase, therefore, only 60,000 cubic yards. Mr. Bazalgette considered this "a very small increase in the total quantity of deposit." But it is equal to 1,620,000 cubic feet, or something more than the entire quantity of fœcal matter cast out in the space of seven months. At that date the outfalls had only been in operation for three or four years, and for a considerable portion of that time very partially. What is the present state of affairs may be soon known from the report of Mr. Rawlinson, who has been instructed by the Home Secretary to inquire into the condition of the river near Barking, the inhabitants of that locality having long ago memorialized the Government on the subject. The article quoted then goes on to show that there are evidences of the salt and sewage of the Thames permeating the bed of the river and contaminating the wells of water works on its banks, as at Crossness. As this is of merely local interest we do not quote it.

STEEL RAILS.—The gradual increase in the price of iron is indicated, not merely by the current quotations, but by the multiplication of blast-furnaces. In the Cleveland district an unusually large number of new furnaces is being erected; and although the production will be thus increased, it will probably be some time before prices will again fall. The gradual tendency to an increase of wages, caused, in part by an unusually strong disposition on the part of large bodies of workmen to emigrate, must tell also in the price of rails. In the mean time, notwithstanding the approaching lapse of Mr. Bessemer's patents, the steel rail trade continues good, and numbers of companies who have decided to employ steel in place of iron, and who must have rails, of some kind, immediately, are ordering freely in steel, the Great Northern Company being now in the market for a thousand tons. The untrue assertion, so industriously repeated in certain interested quarters, that the royalty will be diminished by £2 per ton after February next, is now understood in its true character; and railway companies perceive that even were there no general rise in prices, the diminished royalty will not be more than 18s. or 19s. a ton on that now in force, and of this the companies cannot expect to secure even a half.—*Engineering*.

UTILIZATION OF BLAST-FURNACE SLAG FOR MORTAR.

Compiled and Translated from an article in "Zeitschrift des Vereins Deutscher Ingenieure."

When, in the preparation of mortar, granulated or ground blast-furnace slag is used in the place of sand, a much smaller quantity of lime is necessary to make a well binding mortar, an advantage which is of great importance for many districts. Most blast-furnace slags, containing alumina, lime and silica in certain proportions, are dissolved by acids, the silica only being precipitated in a gelatinous state. The same takes place when natural cement is treated with acids. Blast-furnace slag, like tarrace and cement, contains silica in a condition in

which it is liable to enter new chemical combinations. Silica, in the shape of sand or of quartz, forms, likewise, a chemical combination with the lime in mortar; but only when they have been in contact for a long time. The principal reason why this sand-mortar gets hard, is that the lime combines with carbonic acid taken from the air. As this combination takes place but slowly from the outside, mortar gets hard at first on the surface, the interior remaining soft for some time. If blast-furnace slag of a certain composition is used, the mortar gets hard more rapidly and through its whole mass, because the lime combines with the silica, in the same way as this is the case with tarrace (a kind of puzzolana) or with cement.

Thus mortar, made from blast-furnace slag and lime, hardens:

1. By the formation of carbonate of lime, as ordinary mortar does, and besides,

2. By the formation of chemical compounds of silica and lime.

These reactions are aided and quickened by a repeated contact with water and air. As mortar made from slags hardens quicker and more thoroughly, it does not require near so much lime and produces a more solid mass when hardened. When blast-furnace slag is ground fine it acts considerably better yet in the mortar, and can then be used even as a substitute for tarrace. It is then, also, a good material for plastering.

We communicate in the following the results of experiments, made by a committee of experts, at the Friedrich Wilhelm Iron Works (Prussia), under the direction of Mr. Langen, for the purpose of discovering the qualities and relative value of different materials used in the preparation of mortar and cement:

On the 17th of October, 1861, a number of samples of mortar were prepared from different mixtures, to be tested afterwards when hardened. The materials used were,

1. Fresh calcined lime from Ruppichteroth.

2. Rhenish tarrace, just received.

3. Ordinary sharp sand, as used for masonry.

4. Granulated slag, in pea-size.

5. Fine ground slag.

6. Portland cement of Bonn.

Different mixtures of mortars were prepared from these materials, and small square blocks, 5 in. wide and 2½ in. high, were formed of them in wooden moulds. One-half of these test-blocks were exposed to the air, the other half were laid in wet ground for several months.

On the 12th of March, 1862, the samples were inspected, and were tested as to their solidity and resistance to pressure. The pressure was applied through a lever arrangement. The weight was increased very slowly, and the pieces had to withstand for some time the pressure of a certain weight, before the latter was further increased. The results were the following:

A.—RESULTS OBTAINED WITH SEVEN SAMPLES, HARDENED IN THE AIR.

Number of Sample.	Mixture.	Results of Exterior Inspection — Appearance and Hardness.	Result of crushing test. Sample was crushed by a load of
			lbs.
1.	1 lime. 2 sand.	The sample looked and had hardened like ordinary mortar.....	1,980
11.	1 lime. 1½ tarrace. 1½ sand.	Considerably harder than No. 1...	7,380
3.	1 lime. 3 gro'd slag.	Considerably harder than No. 11. Structure fine and dense.....	17,820
7.	1 lime. 5 gro'd slag.	Harder than No. 3. Equally fine and dense structure...	32,400
10.	1 lime. 2 gro'd slag. 1½ granl. slag.	Harder than No. 7. Structure less fine; the big grs. of slag distinctly visible.....	21,420
13.	1 lime. 1½ gro'd slag. 1½ granl. slag.	Slightly harder than No. 10. Structure similar to No. 10.....	15,080
5.	Pure Portland cement without any sand or lime.	Very hard.....	41,400

B.—RESULTS OBTAINED WITH FIVE SAMPLES, HARDENED IN WET GROUND.

Number of Sample.	Mixture.	Appearance and Hardness.	The sample was crushed by a load of
			lbs.
12.	1 lime. 1 tarrace. 1½ sand.	Not very hard ...	5,600
4.	1 lime. 3 gro'd slag.	Considerably harder than No. 12. Structure fine and dense	11,700
14.	1 lime. 1½ gro'd slag. 1½ granl. slag.	Harder than No. 4. Structure less fine	11,580
8.	1 lime. 5 granl. slag.	Harder than No. 14. Structure fine and dense.....	25,200
6.	Pure Portland cement witho't sand or lime.	Very hard.....	42,800

The above results show that granulated or ground blast-furnace slag is a very valuable material for ordinary and for cement masonry, and that in the property of forming a very solid mortar, it stands in the middle between tarrace and Portland cement, being considerably superior to the former. The tests of the samples No. 7 and 8 prove that a great saving of lime can be effected by the use of slag. Ground slag has, therefore, a much higher value than the best sand. It looks and acts like cement, and shows the same kind of greasiness when mixed with fresh slacked lime. It would be a very valuable ingredient to mix with Porltand cement, to make the latter cheaper, and thus bring it into more extensive use.

S.

PAPER BELTING.—Messrs. Crane & Co. of Dalton, Mass., have succeeded in making belting from paper, and the article is now used in all their own mills and several other manufacturing establishments. The belting is said to resemble the genuine oak-tanned leather, and to serve well both in a dry or damp atmosphere.

HEATING-FURNACE BOILERS.

From "The Engineer."

It is more than probable that as much steam is raised in Great Britain alone during each year, in small boilers, as would cost £150,000, if coal were specially burned to generate it. Furnace boilers may be counted by hundreds, if not by thousands; nearly all the iron we make in this country is smelted, and hammered, and rolled principally by the aid of steam raised from the waste heat or waste gases of our puddling, heating, and blast-furnaces. It might be supposed that everything would be known as to the generate powers of boilers so extensively used; while all that concerns their construction would have been settled on the best principles long since. Yet, strange to say, this is very far indeed from being the case. We have recently had occasion to investigate the subject pretty closely, and we find that the utmost ignorance, and probably, as a consequence, the greatest possible diversity of opinion, exists on almost every point connected with furnace boilers. No one, for example, appears to know how much steam five, ten, or a hundred square feet of heating surface in a furnace boiler should generate in an hour. An engineer putting down new works must, as far any written law goes, be absolutely in the dark. He can of course servilely copy what has been done by other engineers; but it by no means follows that he will of necessity obtain the same results. Boilers put down in apparently nearly the same way in different districts, manifest different powers of evaporation. This is bad enough, but when we turn to questions connected with the safety and durability of boilers, we find them still worse. Boilers are—we believe through ignorance—so badly designed, badly made, and badly set that explosions are of every day occurrence. Shall we say too much if we assert that the boiler engineering of our great iron districts is a disgrace to our profession?

The causes leading up to this result may, we think, be easily indicated. If once fairly examined we also believe that it is quite possible, that means may be found to raise furnace boiler engineering out of the slough of despond into which it seems to have fallen. One reason, then, why the most is not made of the furnace boiler is that it is always regarded as a matter of the most secondary consideration. The first point is that the draught of the furnace must not be inter-

fered with. The boiler must be fitted to the draught, not the draught to the boiler. This is all right enough in one sense, and we willingly admit that when a boiler is used the heat in the stack cannot and should not be as great as though the products of combustion were thrown directly into it. But on the other hand, no one expects the products of combustion to escape from the flues of a furnace boiler at 300 or 400 degrees of temperature. The heat in the first instance is infinitely greater than it is in the flue of a Cornish boiler, let us say, and therefore even after a large proportion has been absorbed much must still remain for the stack. Is it not possible that by lengthening stacks a little it would be practicable to make furnace boilers somewhat more economical than they are?

Another reason why furnace boilers are not what they should be, lies in the fact before referred to, that no one knows how much steam any given boiler can make. No one can tell whether a furnace boiler of given construction is better or worse than another furnace boiler of totally different construction; so long as the iron gets hot soon, every one is satisfied except the manufacturer, who has to pay some thousands of pounds a year for additional steam raised in hand-fired boilers, and this while flame enough to raise twice as much steam as he gets out of these last-named boilers, is pouring from the throats of his re-heating and puddling furnaces. No one knows how much steam can be got out of a furnace boiler, because no one seems to have tried to know. In most ironworks all the boilers are coupled together, and the demand for steam in different parts of the mill is so very variable that it is next to impossible to say how much is being used, or how much is being made by any particular boiler. The only way to settle the point is to select two or three of the best types of furnace boiler, attach a good water meter to one of each type, and conduct a series of observations lasting over a month to determine how much water is really evaporated per foot of heating surface.*

We are convinced that a great field for improvement lies in the designing and construction of boilers to work with heating furnaces, and of heating furnaces to work with boilers. The sooner the matter is taken up, ventilated, and discussed, the better. At this moment keen competition has reduced the profits of the ironmaster so low that he has no money to waste in rising steam. Can none of our correspondents in the mining and ironmaking districts aid us to throw some light on the subject? Every scrap of authentic information is of value as tending to form a nucleus round which other facts may gather. Few subjects deserve more attention than furnace boilers at this moment, and we shall be pleased to hear what our practical readers have to say for and against particular types of boiler. A free discussion of the subject will be certain to do good; and such a discussion we hope to see started in our correspondence columns.

* This is a recommendation of the highest importance, and we hope it will be followed up in this country. We have recently got at some approximate results as to the evaporation in a boiler 30 ft. long, and 50 in. diameter, with two 17-inch flues, when used over a furnace *heating steel* rail ingots. The evaporation was only about one quarter as much as in the same style of boiler set in a battery, Cornish fashion and fired in the ordinary manner.—Ed. V. N. M.

ARCHITECTURE CONNECTED WITH STRUCTURES OF CIVIL ENGINEERING.

From a Paper read before the Society for the Encouragement of the Fine Arts, June 10, by Thomas Page, C. E., Acting Engineer of the Thames Tunnel, and Engineer of the New Westminster and Chelsea Bridges.

Considering that so many hundreds of millions of money have been expended in these kingdoms in works of civil engineering, and that in too many cases these works have not been distinguished by that architectural knowledge which has never been neglected in past ages, and very rarely indeed on the Continent, it is not surprising that the Council of a Society for the Encouragement of the Fine Arts, having before them the great examples of bygone days, when works of utility were coupled with artistic treatment, should draw attention to this subject at the present time, with the object of promoting a union of engineering science with the most severe of fine arts—viz: architecture.

During many ages the various kinds of works now appertaining to the civil engineer were executed by architects, and, as you are aware, the first architects were the kings and priests of the early ages. The constructors of the moles of Tyre and Sidon, the harbor of Alexandria, the port of Ostia, and all such undertakings, which were especially works of *utility*, were in reality done by engineers who were nominally architects. When, in process of time, these works of ultility increased in number and variety, in

consequence of the extension of commerce and manufactures, they were entrusted to a class of men named *civil* engineers, to distinguish them from the *military* engineers, whose duties were those of attack and defense, while the former were engaged in the construction of roads, bridges, harbors, lighthouses, docks, and other hydraulic works, with their engines and machinery; and, lastly, on railways, of which about 14,300 miles have been executed in the United Kingdom.

The profession of the civil engineer is one of great importance in all progressive nations, and its members should be worthy of a calling which has numbered among its members the kings and priests of early ages, the Pontifex Maximus of the Romans, and the Christian Popes, the Cæsars, the Roman generals, and those succeeding them, down to the Great Napoleon, the offspring of the French Revolution, and the present talented Emperor, who, trained some time in England in the school of adversity, now occupies the throne of the French Empire, and exercises a controlling power in the European States.

In this country, the origin of the profession of civil engineers has been well defined in the preface to the reports of the eminent engineer, John Smeaton (the engineer of the Eddystone Lighthouse). These reports were published in 1812, and and although of great interest to persons who regard the profession of the civil engineer as an object of study, need not be further alluded to than in the following sentence.

The memoir states: "Civil engineers are a self-created lot of men, whose profession owes its origin, not to power or influence, but to the best of all protection, the encouragement of a great and powerful nation; a nation become so from the industry and steadiness of its manufacturing workmen and their superior knowledge in practical chemistry, mechanics, natural philosophy, and other useful accomplishments." From this rapid but preliminary sketch, I now come to the artistic division of the subject—"Architecture connected with structures of civil engineering," and I would draw your attention to the fact that the greater the dimensions of the structure, provided the outlines are graceful, the less the effect which can be produced by architectural decoration, because the mind, impressed by the vastness and beauty of the outlines, by the leading features of the structure, regards in a less degree those architectural features which in structures of minor importance are so pleasing. As an illustration of this idea, I will refer to two buildings which you may all know—viz: the beautiful Water Gate of Inigo Jones, now at the river end of Buckingham-street, Adelphi, and the noble structure of London Bridge, the work of the great engineering family of the Rennies. Every detail in the Water Gate is well worthy of study, and produces a most pleasing effect; but in the great structure of London Bridge, although the dentiled cornice and the simple parapet are so well adjusted as to form a most successful example of architectural application well worthy to be imitated, yet the size and proportion of the arches and piers are such that the architectural details are almost lost in the vastness and majority of the whole.

Referring back to the early works of utility, I would state that among the works of the Romans of an engineering character may be especially named those great aqueducts which supplied such volumes of water into Rome and other cities of the extended empire. These structures of essential utility were rarely devoid of architectural treatment. In some, the masonry was rusticated, the arch stones being plain, in others pilasters spring from the first tier of arches, as in the aqueduct of Merida in Spain. The division of the height of the aqueduct into arches upon arches, not only secured stability in structures so narrow, but formed a pleasing architectural effect, and a series of arches of a lesser span surmounting the whole, on which was carried the channel for the water, formed as it were an ornamental attic story, examples of which were given in the Aqueduct du Gard, that of Theodoric at Spoleto, and others. The practice of introducing small arches in the highest story of the aqueducts is followed by the architects of France as may be seen in the noble structures of Roquefavour, of recent construction, and that of Montpellier, of the last century.

There are two structures of early times to which I would especially refer on account of their lofty proportions. These are, the bridge at Alcantara, constructed in the reign of Trajan, and the Aqueduct of Spoleto, attributed to Theodoric, the truly great Gothic King of Italy, who died A. D. 526. The bridge, or "Alcantara," was constructed over the Tagus, in a depth of 40 feet of water, A. D. 105; and its height above the level of the river is 245 feet, making a total height of 285 feet, which is 80 feet higher

than the towers of Westminster Abbey. It is to be deeply regretted that one of the arches of this noble structure was blown up by the British army in June 1810, when Marshal Victor menaced to cross the bridge. As to the Aqueduct of Spoleto, there are various accounts of its height. Some statements, among which is that of Gauthey, assign to it an elevation of 130 meters, while others state that it does not exceed 82 meters. The immense aqueduct which supplied Carthage, and of which Dr. Davis, the explorer of Carthage, and author of the work "Carthage and Her Ruins," has given a photograph in the frontispiece of his work, is 60 miles in length.

The character of the architectural treatment of an engineering work must of course depend upon the outline and style of the design. In a suspension bridge, the architecture of the piers is difficult, because so few forms will harmonize with the curve of the chains. In the design of the Chelsea Bridge, the piers consist of iron frames protected by an ornamental casing; each is surmounted by a large globe as a lantern. If any professional architect will examine the mouldings of the Chelsea Bridge, he will be pleased, I think, with their form and certainly will admire their execution.

But it is not, in suspension bridges, however noble and beautiful, as in the Menai Bridge, constructed by the great engineer Telford, so well known for his practical knowlege and his taste, that we must seek for the artistic feelings which this society desires to encourage. It is in the application of the arch, which in general can be applied under all circumstances, and which so well admits of architectural treatment. I have spoken of London Bridge, Waterloo Bridge, and Southwark, and I would now refer you to two designs of my own—one for Blackfriars, which was selected by the Committee of the Bridge House Lands for adoption, and the other is the approved design for Westminster Bridge. As the two designs are widely different, the treatment of them will explain my ideas of "Architecture connected with structures of civil engineering."

The great spans of the segmental arches of Blackfriars, the center arch of which is 280 feet, require piers of proportionate thickness; these are terminated above the cutwaters by massive pedestals of polished granite, intended to have been obtained from the quarries in the Ross of Mull, on part of the estate of the Duke of Argyll. These pedestals are surmounted by groups of sculpture selected from events in British history, which, in their elevated position, would have been seen with a sky outline, a condition so important for the best effect.

The imposing sweep of the arches renders ornament almost uncalled for, and so the spandrels only have an ornamented character, in which is introduced the River God and the armorial bearings of the City of London; the cornice is simple, and the parapet plain. In Westminster Bridge, on the contrary, the arches are of moderate span, the center being only 120 feet, although the radius of curvature is 250 feet, which would, with the same material at the crown, be sufficient for a semicircular arch 500 feet in span. The piers are narrow, the arches spring from a horizontal line, and sweep gently towards the center in an easy curve. This curve in the design was struck by my hand, and my assistants were directed to find what figure it was, when it was ascertained that it was a curve parallel to an ellipse. The arches, as you are aware, are not pointed arches, and it was therefore denied that the bridge is a Gothic bridge, but the arches on the tomb of Henry V. in the Confessor's Chapel at Westminster Abbey are elliptic arches, and there are examples of elliptic arches even in Norman architecture.

In such a design, then, as Westminster Bridge, it was consistent that the spandrels, cornice, and parapet, should be of an ornamental and heraldic character, and accordingly it bears in its spandrels and the panels of its pedestals the Royal Arms of the United Kingdom—those of the lamented Prince Consort; of the Prince of Wales, and the Ministers and Chief Commissioners of Her Majesty's Works who held office at the time. Instead of the massive pedestals of Blackfriars, Westminster shows a delicate and finely-worked pedestal, surmounted by the lamp standards.

To Westminster I may add the Lendal Bridge at York, of a still more ornamental character, and in which the angel which supports the Royal Arms in the center of the arch, was copied from the portrait of the Princess of Wales.

The beautiful Point du Carrousel at Paris, the work of the engineer M. Polonceau, claims our admiration as a cast iron structure, and I need not say that Paris offers many examples of stone bridges treated in a masterly, artistic style, which do honor to the taste of the Emperor.

To determine the ornaments and mouldings for a work of the civil engineer, must depend upon great knowledge and refined taste; the buildings of the crypts, such as Westminster and Lambeth, for heavy works; those of Henry III, where admissible, according to the proportion of the arches, are most fitting; if in designs, where the Tudor arch is introduced, then the mouldings of that age. And I may here state that of all works where science and art are wonderfully combined, there has been no work before or after its time more wonderful than that extraordinary construction, the gem of Gothic architecture, the roof of the Chapel of Henry the Seventh. You must ever keep in view that the progress and perfection of artistic designs are the results of great and powerful minds, and that the employment of mediocre persons without knowledge and without taste, however wealthy may be the practitioners, must ever be a retardation to progress and discreditable to the country.

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf.

Translated from "Annales du Génie Civil."

(Continued from page 624.)

In the surface condenser, the feed water being distilled and condensed, without mingling with cold water, there can be no back-pressure due to the gases; consequently, in the general equation (No. 5), we must cancel the terms relating to that part of the back-pressure. There is also no injection water, and the term affected by $\mu\,\Sigma$ is, therefore, equally canceled.

Equations of work in the surface condenser.—Taking into account these modifications, Eq. 5 becomes adapted to the surface condenser in the following form:

$$T\,c\,s = \tfrac{1}{3}\,S\,L\left[(P-f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\,(1-\cos\left(\frac{q\,(650-\theta)}{R_s\,\tau\,a'}\right)+3f \quad . \quad . \quad . \quad . \quad . \quad (13),$$

in which $\beta = 0$; for here, even more than in the injecting condenser, the heat absorbed by the condensed water may be neglected.

For metallic surfaces well cleaned we have Eq. (8).

$$a' = \frac{k}{e}\,\sigma\left(a-b\right).$$

Since a is the mean temperature of the interior surface of the condenser and varies between Θ and θ. (Θ = the temperature of steam as it enters at the pressure $\frac{P}{1+r}$) we may put

$$a = \frac{\Theta+\theta}{2}.$$

Since b is the mean temperature of the exterior surface of the condenser, if the water is rapidly circulated (a matter very essential to the good performance of the apparatus), we may admit b to be equal to the mean temperature of the water, both at the entrance and exit. As the interior surface is always covered with a very thin layer of stagnant water of condensation, and the exterior surface, notwithstanding the renewal of the water, is covered by an analogous deposit of stagnant water, protected by the rugosities of the metal, we must allow, according to Pèclet, that a' is independent of the thickness of the walls, and is simply

$$a' = k\,\sigma\,(a-b)$$

But for the co-efficient k we cannot now use the number 19.11 (in the case of a copper condenser), for a wall whose surfaces are obstructed throughout the operation, since this co-efficient is applicable only on the assumption of a perfect renewal at every instant of the water in contact with the exterior surface. We must adopt, then, the co-efficient 1.6, which results from the experiments of M. M. Thomas and Laurens, for the conducting power of copper under these conditions.

2. Case I.—*Copper condenser with clean surfaces.*—We have, then, for the condenser with clean surfaces,

$$T\,c\,s = \tfrac{1}{3}\,S\,L\left[(P-f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\,(1-\cos\frac{q\,(650-\theta)}{R_s\,\tau\,\sigma\,(a-b)}\,\frac{1}{k}\right)+3f\Big] \quad . \quad . \quad . \quad . \quad (14),$$

in which expression $k = 1.6$. We shall employ k' with a value of 19.11, instead of k, when applicable to a wall whose surfaces are constantly washed by water.

3. There is between σ and θ a necessary relation, due to a periodical equilibrium, which we must assume to exist in the condenser, for we must consider the action of this apparatus from the instant at which the temperature θ becomes constant. From that instant the quantity of heat brought to the condenser by each stroke of the piston, diminished by the quantity retained by the condensed water, ought to pass through the surface σ in a time equal to the duration of a piston stroke. The quantity of heat brought by each stroke is $q \times 650$, and the

quantity to be transmitted is $q\,(650-\theta)$. The quantity which the surface will transmit in a unit of time is $k\,\sigma\,(a-b)$; and in the time τ, or one piston stroke, $\tau\,k\,\sigma\,(a-b)$; but in taking into account the retardation expressed by the co-efficient R_s it becomes $R_s\,\tau\,\sigma\,(a-b)\,k$. Hence the equation $q\,(650-\theta) = R_s\,\tau\,\sigma\,(a-b)\,k$; and

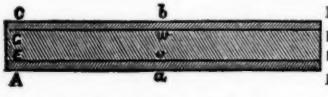
$$\sigma = q\,\frac{650-\theta}{a-b}\,\frac{1}{R_s\,\tau}\,\frac{1}{k} \quad . \quad . \quad . \quad . \quad (14a).$$

This equation gives the minimum value σ for a given value of θ. It also clearly expresses this condition of the value of σ, that the act of condensation is simultaneous, both in its duration and termination, with the stroke of the piston. If, also, for any value of θ the surface is less than this minimum, the equilibrium will ensue at a normal temperature higher than θ. On the other hand, if the effective surface be $N\,\sigma$ (supposing $N > 1$) the work of the condenser will be less than in Eq. (14), which expresses a maximum, the effective work now being

$$T\,c\,s = \tfrac{1}{3}\,S\,L\left(\frac{P-f}{1+r}\cdot\frac{1}{N} + 3f\right). \quad (14b)$$

N being the ratio of the actual surface to the minimum surface.

4. SECOND CASE.—*Condenser incrusted on its interior surface.*—We will take the case of a plate of metal of the thickness e, covered with an incrustation of low conducting power of the thickness η, and having for a co-efficient of interior conductibility γ.



The face A B of the crust is in contact with the steam and transmits the heat to the metallic plate. This face, then, has the mean temperature a; the metallic face C D has a mean temperature b; the face E F common to the metal and the crust will then have an unknown mean temperature u. The quantity of heat transmitted per unit of time and per unit of surface of the crust is $\frac{a_1}{\sigma_1} = \frac{\gamma}{\eta}\,(a-u)$. At the moment of thermal equilibrium this quantity is equal to that which passes through the metal, having for its expression $\frac{a_1}{\sigma_1} = \frac{k'}{e}\,(u-b)$. Hence

$$\frac{k'}{e}\,(u-b) = \frac{\gamma}{\eta}\,(a-u)$$

Eliminating u

$$a_1 = \frac{k'\,\gamma}{k'\,\eta+\gamma\,e}\,\sigma_1\,(a-b) \text{ or } a_1 = \frac{1}{\frac{\eta}{\gamma}+\frac{e}{k'}}\,\sigma_1\,(a-b)$$

Substituting in Eq. (13) this value a_1

$$T\,c\,s_1 = \tfrac{1}{3}\,S\,L\left[(P-f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left\{1-\cos\frac{q\,(650-\theta)}{R_s\,\tau\,\sigma_1\,(a-b)}\left(\frac{\eta}{\gamma}+\frac{e}{k'}\right)\right\}+3f\right]. \quad (15)$$

With the expression for the minimum of surface

$$\sigma_1 = q\left(\frac{650-\theta}{a-b}\right)\frac{1}{R_s\,\tau}\left(\frac{\eta}{\gamma}+\frac{e}{k'}\right)$$

or

$$\sigma_1 = q\left(\frac{650-\theta}{a-b}\right)\frac{1}{R_s\,\tau}\cdot\frac{1}{\gamma}\,\eta + q\left(\frac{650-\theta}{a-b}\right)\frac{1}{R_s\,\tau}\cdot\frac{e}{k'} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15a)$$

and

$$T\,c\,s_1 = \tfrac{1}{3}\,S\,L\left(\frac{P-f}{1+r}\cdot\frac{1}{N_1}+3f\right). \quad (15b)$$

5. THIRD CASE.—*Condenser incrusted on the outside.*—If the exterior face is alone covered with a crust of the thickness ε, and of the conductibility κ, we shall have expressions anologous to Eqs. (15) and (15a), in which we may replace η by ε, and γ by κ, make $e = 1$, whatever the thickness of the metal, and replace k' by k. Thus,

$$a_1' = \frac{1}{\frac{\varepsilon}{\kappa}+\frac{1}{k}}\cdot\sigma_1'\,(a-b).$$

$$T\,c\,s_1' = \tfrac{1}{3}\,S\,L\left\{(P-f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left[1-\cos.\frac{q\,(650-\theta)}{R_s\,\tau\,\sigma_1'\,(a-b)}\times\left(\frac{\varepsilon}{\kappa}+\frac{1}{k}\right)\right]+3f\right\} \quad (16)$$

$$\sigma_1' = q\left(\frac{650-\theta}{a-b}\right)\cdot\frac{1}{R_s\,\tau}\left(\frac{\varepsilon}{\kappa}+\frac{1}{k}\right) \text{ or}$$

$$\sigma' = q\left(\frac{650-\theta}{a-b}\right)\frac{1}{R_s\,\tau}\cdot\frac{1}{\kappa}\,\varepsilon + q\left(\frac{650-\theta}{a-b}\right)\frac{1}{R_s\,\tau}\cdot\frac{1}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16a)$$

and

$$T\,c\,s_1' = \tfrac{1}{3}\,S\,L\left(\frac{P-f}{1+r}\cdot\frac{1}{N_1'}+3f\right) \quad (16b)$$

6. FOURTH CASE.—*Condenser incrusted on both faces.*—Suppose a metallic plate of the thickness e, covered with a crust of the thickness η, and of the conductibility γ on its interior face (as in § 4), and with another crust of the thickness ε and conductibility κ on its exterior face (as in § 5). Let u and w be the unknown temperatures of the faces of contact E F and G H of the metal and

crusts. During the equilibrium of temperature the quantity of heat passing in a unit of time through both of the crusts and through the metal will be the same. This quantity, considered as passing through the crust A B E F, is, according to § 4,

$$\frac{a_{II}}{\sigma_{II}} = \frac{k'\gamma}{k'\eta + \gamma\varepsilon}. \quad (a - b).$$

Considered as passing through the crust C D G H it will be

$$\frac{a_I}{\sigma_{II}} = \frac{\kappa}{\varepsilon} \quad (w - b); \text{ hence,}$$

$$\frac{\kappa}{\varepsilon} (w - b) = \frac{k'\gamma}{k'\eta + \gamma\varepsilon} (a - b);$$

and eliminating w,

$$a_{II} = \frac{1}{\frac{\varepsilon}{\kappa} + \frac{\eta}{\gamma} + \frac{e}{k'}}. \quad \sigma_{II} (a - b)$$

and the equation of work becomes

$$T c s_{II} = \tfrac{1}{3} S L \left\{ (P - f) \frac{1}{1 + r}. \quad \tfrac{1}{2}\left[1 - \cos. \frac{q (650 - \theta)}{R_e \tau \sigma_{II} (a - b)} \left(\frac{\varepsilon}{\kappa} + \frac{\eta}{\gamma} + \frac{e}{k'} \right) \right] + 3f \right\} \quad (17)$$

for the minimum of surface

$$\sigma_{II} = q \frac{650 - \theta}{a - b}. \frac{1}{R_e \tau \kappa} \varepsilon + q \frac{650 - \theta}{a - b}. \frac{1}{R_e \tau \gamma} \eta + q \frac{650 - \theta}{a - b}. \frac{1}{R_e \tau k'} e \quad . \quad (17a)$$

and

$$T c s_{II} = \tfrac{1}{3} S L \left(\frac{(P - f)}{1 + r}. \frac{1}{N''} + 3f \right) \quad (17b)$$

7. By equations (15*a*), (16*a*), (17*a*), it appears that if θ be considered as a constant, and η and ε as variables, the function σ increases very rapidly in proportion to any increase of these quantities, for the equations represent a line or plane making a small angle with the axis of σ, while, as factors, the co-efficients $q \frac{(650 - \theta)}{(a - b)} \cdot \frac{1}{R_e \tau \kappa}$ and $q \frac{(650 - \theta)}{(a - b)} \cdot \frac{1}{R_e \tau \gamma}$ are always very large. This shows that, if we are considering a given temperature θ, the surface condenser must have a minimum cooling surface $= q \frac{650 - \theta}{a - b} \cdot \frac{1}{R_e \tau \kappa}$ relative to the incrusted metal. But if we wish to omit a specific determination of the influence of incrustations we must give to the surface a much greater extent than this minimum value, and one increasing rapidly with the thickness of the scale. Hence, as I have shown in § 2, these equations express a condition of the minimum of surface, regard being had to the development of crusts; and if this minimum ceases to be obtained by reason of that development, the temperature θ will increase until the equation of the minimum is satisfied.

8. *Maximum conductibility of the metal.*—Before discussing the equations relating to the surface condenser, it may be well to examine an experimental fact, which is very singular, and appears to be somewhat parodoxical, but upon the certainty of which engineers seem to agree. According to Péclet (who has given a plausible explanation of it by observing that a slight incrustation increases the surface, by reason of the rugosities which it produces), perfectly clean metal transmits less heat than when it is slightly incrusted. We have stated that the co-efficient of the conductibility of the metal may have two widely different values, according to whether, or not, it is placed in immediate contact with the heating body on one side, and the cooling body on the other. It follows from the experiments of Péclet, that when this immediate contact takes place (as when the surfaces of the metal are continually washed, so that the film of adherent water is perpetually renewed at every instant), the quantity of heat passing through the metal in a given time is in an inverse ratio to the thickness of the metal. But if there is no such renewal of the adherent film, the quantity of heat transmitted has no definable relation to the thickness of the plate. This is a consequence of the high conductibility of metallic bodies (the fact is quite otherwise with bad conductors); that is, in the first case, the quantity is expressed for a unit of surface and time by $k' \frac{a - b}{e}$ and in the second case by $k\ (a - b)$. In the case of copper k' is, according to Péclet, 18.11, and according to the experiments of M. M. Thomas and Laurens $k = 1.60$.

The difference between the co-efficients k and k' will furnish an explanation of the experimental fact which we have stated. The quantity of heat transmitted by a plate in a unit of time and per unit of surface is:

(1). In the case of metal well cleaned, but not washed during the act of absorption:

$$a' = k\ (a - b).$$

(2). In the case of incrustation of that face only which receives the heat:

$$a_I = \frac{k'\gamma}{k' + \gamma e} (a - b)$$

(3). In the case of incrustation of that face only which emits the heat:

$$a_{,}' = \frac{k\,\kappa}{k\,\varepsilon + \kappa}\,(a - b)$$

(4). In the case of incrustation of both faces:

$$a_{,,} = \frac{k'\,\gamma\,\kappa}{k'\,\gamma\,\varepsilon + k'\,\kappa\,\eta + \gamma\,\kappa\,e}\,(a - b)$$

and for copper we have the values

$$k = 1.60 \text{ and } k' = 19.11$$

Generally a' is greater than each of three other quantities, $a_{,}$, $a'_{,}$, $a_{,,}$, and hence

$$\left.\begin{aligned} k\,(a-b) - \frac{k'\,\gamma}{k'\,\eta + \gamma\,e}\,(a-b) &> 0 \\ k\,(a-b) - \frac{k\,\kappa}{k\,\varepsilon + \kappa}\,(a-b) &> 0 \\ k\,(a-b) - \frac{k'\,\gamma\,\kappa}{k'\gamma\,\varepsilon + k'\kappa\,\eta + \gamma\,\kappa\,e}(a-b) &> 0 \end{aligned}\right\} \quad (19)$$

Now it is possible that for certain values of ε and η these inequalities may change signs, and this change would be a confirmation of the fact stated. But if these inequalities change signs, they must pass through the value of zero, and conversely if they pass through the value of zero, they must change signs. Hence, if we take for the various cases above the following equations

2d case, $k = \dfrac{k'\,\gamma}{k'\,\eta + \gamma\,e}$

3d " $k = \dfrac{k\,\kappa}{k\,\varepsilon + \kappa}$

4th " $k = \dfrac{k'\,\gamma\,\kappa}{k'\,\gamma\,\varepsilon + k'\,\kappa\,\eta + \gamma\,\kappa\,e}$

we ought to be able, if the fact stated really exist, to deduce for η and ε values greater than 0.

In the second equation $\varepsilon = 0$; hence, the fact in question does not appertain to the case of incrustation of the emitting face—a result agreeing well with the explanation proposed by Péclet; for, in the case considered, no incrustation exists upon the wall which receives the heat, the absorbing surface is in no wise affected, and it can therefore give no maximum of conductibility. From the first equation we deduce

$$\eta = \gamma\left(\frac{1}{k} - \frac{1}{k'}\,e\right)$$

This value is positive for $e < \dfrac{k'}{k}$.

For copper $\dfrac{k'}{k} = \dfrac{19.11}{1.6} = 12$, e does not exceed 2 millim. Hence, the fact in question exists only in the case of incrustation of the face which receives the heat. The value of η resulting from this equation will depend upon the values of γ and e. We will suppose $e = 1$ millim., for the tubes of surface condensers.

In condensers the scale is a coating formed by the dust brought in by the steam, with oxide of iron, oxide or carbonate of copper, oxide of lime, magnesia, sulphate of lime, &c. Its coefficient will be intermediate between the following, given by Péclet:

Powdered brick	.14
Powdered chalk	.108
Iron filings	.157
Peroxide of manganese powdered	.163
Mean	.14

We may therefore make $\gamma = .14$, giving for surface condensers

$$\eta = .14\left(\frac{1}{1.6} - \frac{1}{19.11}\right) = .08 \text{ m. m.}$$

From the 3d equation we derive

$$\varepsilon = \kappa\left(\frac{1}{k} - \frac{1}{k'}\,e - \frac{1}{\gamma}\,\eta\right)$$

The external crust is formed, generally, of carbonate of lime and free magnesia, and presents some analogy to the internal crust. We may, therefore, put $\kappa = \gamma = .14$, and hence

$$\varepsilon = .14\left(\frac{1}{1.6} - \frac{1}{19.11} \times 1 - \frac{1}{.14}\,\eta\right) \text{ or}$$

$$\varepsilon = .14\left(.57 - \frac{1}{.14}\,\eta\right)$$

The nearer η approaches in value to zero, the more nearly does ε approach to $.14 \times .57 = .08$, and in proportion as η increases, ε diminishes, until it becomes zero. Therefore the thickness of the crust corresponding to the maximum of conductibility in the surface condenser cannot exceed .08 m m.

It must be remarked here that when ε and η vary from the values just assigned, the second terms in Eq. 19 decrease very rapidly. By substituting for γ, κ their value .14, these terms become respectively

$$\frac{1}{\frac{\eta}{.14} + \frac{e}{k'}} \text{ or } \frac{1}{7.14\,\eta + \frac{e}{k'}}$$

$$\frac{1}{\frac{\varepsilon}{.14} + \frac{1}{k}} \text{ or } \frac{1}{7.14\,\varepsilon + \frac{1}{k}}$$

$$\frac{1}{\frac{\varepsilon}{.14} + \frac{\eta}{.14} + \frac{e}{k'}} \text{ or } \frac{1}{7.14\,\varepsilon + 7.14\,\eta + \frac{e}{k'}}$$

These quantities measure the efficiency of the condenser, for it is by these quantities that we must multiply the extent of surface, and the difference of temperatures $(a - b)$, to obtain the respective quantities of heat transmitted in a unit of time.

9. Let us now compare Eq. 14 expressing the work of a clean surface condenser with Eq. 7 relative to the injecting condenser, resuming in the latter the co-efficient R. Replacing the cosine by its value as a function of its arc, these equations become

$$Tcs = \tfrac{1}{3} S L \left[(P - f) \frac{1}{1+r} \frac{q^2 (650 - \theta)^2}{4 R_s^2 \tau^2 \sigma^2 (a-b)^2} \frac{1}{k^2} + 3f \right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14a)$$

$$Tci = \tfrac{1}{3} S L \left[(P - p) \frac{1}{1+r} \frac{q^2 (650 - \theta)^2}{4 R_1^2 \tau^2 \Sigma^2 (\Theta - t)^2} + 3p \right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7a)$$

Suppose that the two condensers are equal in all respects, excepting those elements which characterize the two systems. We shall then have

$$\frac{Tci - p}{Tcs - f} \frac{S L}{S L} = \frac{P - p}{P - f} \cdot \frac{(a-b)^2}{(\Theta - t)^2} \cdot \frac{1+r}{1+r} \cdot \frac{k^2}{\mu^2} \cdot \frac{\sigma^2}{\Sigma^2} \cdot \frac{R_s^2}{R_1^2}.$$

Now $\frac{P - p}{P - f}$ is < 1 since $p = f + f_1$; also $\frac{(a-b)^2}{(\Theta - t)^2}$ is evidently < 1; k, the co-efficient for the case of metal cleaned, but having a very thin film of stagnant water upon its surface, is necessarily smaller than μ, the co-efficient of the exterior conductibility of the water; for k includes both the effect expressed by μ and the resistance of the metal to the passage of the heat. We have then

$$\frac{T c i - p S L}{T s c - f S L} < \frac{\sigma^2}{\Sigma^2} \cdot \frac{R_s^2}{R_1^2}.$$

Hence the work due to the retardation of condensation in the two kinds of condensers varies more rapidly than the inverse ratio of the squares of the surfaces σ and Σ, multiplied by the square of the ratio of the co-efficients R_s and R_1, which is less than unity.

This inequality serves as a measure of the general superiority in principle of injecting over surface condensation through metallic plates, even without considering the effects of incrustation, which we have partially discussed. This superiority is very decided; 1st, because σ is limited by the cost of apparatus and by the space it requires, and because it is constant for a given apparatus, while Σ can be increased very considerably without increase of space or power, and can be varied at pleasure; 2d, because the co-efficient R_s, which depends upon the friction of the steam in the tubes of the condenser and the resistance of the air in these tubes, is very small in comparison with R_1. The principle of injection ought not therefore to be abandoned without some absolute necessity, and I shall show hereafter that no such necessity exists.

(To be continued.)

TUBE SETTING.

From "The Practical Mechanic's Journal."

Were we to go back to the commencement of the uses of tubes, when the necessity of their being fixed in series with either air, steam, or water-tight joints in tube-plates began to be understood, we should have a somewhat lengthy, but, nevertheless, interesting history of one most important detail in mechanical engineering practice to follow out. We should have to lay down in order the trials made with "tubulous" as well as tubular boilers prior to the St. Etienne experiments of 1828, to record the anxious overlooking and months of heavy toil undergone by Henry Booth, Robert Stephenson, and, we believe, Launcelot Young, in getting the "Rocket" boiler ready for the Rainhill competition; whilst in attending to this branch of tube-fixing alone any record would be but very incomplete, as it would leave out of consideration numerous other cases wherein an effectively fitted tube and plate-joint have been found essential, as in the instances of surface condensers, brewery refrigerators, coolers, *et hoc genus omne.*

Yet, however much the effective fixing of tubes has been found an engineering difficulty to carry out with close regard to economy, the methods adopted in the several instances which we have enumerated are each totally different; and compulsorily so, from the conditions governing every individual case.

In the case of a steam-boiler, the joint is required to remain tight and secure under various and, more usually, very high pressure of steam, at correspondingly intense degrees of temperature; to resist which it is necessary to insure almost atomic contact between the metal of the tube and tube-plate. Thus,

expedients are resorted to, whereby intense permanent local pressure to maintain the imperative degree of metallic contact may be derived. In the case of a high pressure boiler (locomotive, for example, with the spring balance set to allow the safety-valve to blow off steam at from 120 to 150 lbs. pressure per square inch), it is almost impossible to secure by mechanical appliances, in every case, that degree of closeness of the joints so that all of them in any given boiler will be tight; wherefore it is no unusual thing to find that after all the care of the boiler-smith has been used by driving conical drifts, and followed up by the (until lately) nearly universal method of driving in conical cast iron expanding ferrules, some 40 per cent of the tube joints leak. But a boiler is *self-curative*, and we have often been on a locomotive engine running its trial mileage, with steam and water bubbling and hissing out from the tube joints at both fire-box and smoke-box ends to a highly injurious degree, yet we have examined the same boiler a few days, and sometimes a few hours afterwards, and found the leakage had stopped. But in the case of surface condensers, refrigerators, and so on, the effects of high temperature and rapid corrosion through the pressure of a corroding (*i. e.* oxidizing) liquid passing very rapidly over the leaky parts of the metallic joint do not obtain; therefore certain kinds of elastic packing, which remain uninjured at low temperatures have come into use, either of hemp, flax, india-rubber, or other fibrous or expansive material; and these have been, and continue to be, employed in a variety of forms.

In the present paper we desire more particularly to direct attention to the methods and tools employed for fixing tubes in steam-boilers; and in every case, except in one very important example with which we are acquainted, it is well here to state that such fixing is effected by *expanding* the tube end to fill the hole made in the tube-plate; whilst in most cases of surface condensers and refrigerators the tightness is secured by the *compression* of some elastic packing between the outer surface of the tube and the inner surface of the hole or recess in the tube-plate.

In regard to the fixing of tubes in boilers, the expansion of the tube end to fit the hole in the tube-plates was for a long time universally effected by the mere driving, by hammer, of a conical drift into the tube; and as the holes in the tube-plates were bored parallel, the tubes could not by this method be made to thoroughly fill the holes except at the extreme outer ends, or where the drift was of maximum diameter; nevertheless, in moderately pressed, and, indeed, we have known many cases of very highly pressed boilers, this method for a long time was the best known—additional tightness of the joint being secured by caulking the tube end and plate whilst the drift was inserted.

Afterwards, to increase the efficiency of the foregoing method of fixing by drifting, cast-iron truncated conical ferrules were introduced, so as to maintain a constant outward pressure of the tube end into the tube-plate hole; but these were found to be sources of trouble, producing difficulties in the way of cleaning the tubes, also constituting prominences at the smoke-box end, whereby small pieces of coke, coal, and ash, which, had the tubes been free from such obstruction, would have passed through them, were retained; therefore, in many cases wherein the cast iron ferules had been used, they were abandoned, and return was made to the fixing by drifting and caulking alone.

In a steam-boiler a well-fitted tube serves two purposes, namely, the provision of heating surface, and it also acts as a longitudinal stay; this latter feature has, however, in many designs for tube-fixing been entirely over-looked, more especially by French engineers, several of whom have proposed plans by which the tubes may be removed for both interior as well as exterior cleansing and scraping; but these devices are generally of that order which incurs the expense of very costly fittings, besides taking up so much more room in the tube-plate that the effective heating surface of the boiler is diminished, through the mere impossibility of putting in so large a number of tubes; and the tubes, when applied by such methods, constitute but very inefficient stays, and for this reason, we believe, have never been widely applied.

As to the importance of some not yet devised method by which the presently admissible number of tubes in a multitubular boiler may be maintained, and the tubes themselves rendered capable of expeditious removal and replacement, there cannot be a question; and the discovery of such a method promises a sure and certain reward to the inventor. For, at present, when a tube has to be removed, it is altogether useless for

being replaced in the same boiler, because the ends are generally corroded into chemical unity with the tube-plate, and are bent and battered about into various tortuous forms, besides being split in the separation. Nor is this all the injury done, for it frequently happens that the hole in the tube-plate is thrown so much out of form by rust and cutting, that it has to be re-bored—that is, enlarged—to render it fit for receiving a new tube. The loss incurred through the destruction of the tube ends was felt to be so serious in one factory with which we are acquainted, that a few years ago the superintending engineer proposed to employ a knife-cutter, working in a lathe, for the purpose of squaring off the ends of the injured tubes; and he further proposed to use them again by putting on a short length of tube at one of the ends, jointing the two together by brazing over an interior ferrule. We are not sure whether the proposal was carried out extensively, and we even doubt if it could be economically and with general success adopted, for many practical difficulties appear to us to lie in the way. Of late years some of the defects to which we have alluded have been partially overcome by the introduction of tools for cutting the ends off the tubes before they are removed.

To return, however, now to consider the methods and tools employed for expanding the ends of the tubes outwards so as to fit the tube-plate holes.

Some years ago, when the necessity for doing this in a more rapid manner than by the "hammer and plug" method was seriously felt, several forms of expanding mandrels cropped up, some actuated by screw pressure, and others by hydraulic pressure; but all these have now yielded to those forms of tube expanders in which the expansion is produced by the stretching action of a series of rollers revolving inside the tube and pressed outwards by means of a central cone. Until quite recently the tool made by Dudgeon, of New York, was undoubtedly the most rapidly acting, and in all respects the best tool for the purpose which engineers possessed. Yet Dudgeon's expander has some defects, amongst which we may mention the impossibility of producing a parallel expansion of the whole length of the expanded part of the tube, so as to fit perfectly the hole in the plate, except when the central taper mandrel is driven fully in, so that the parallel upper end of it bears throughout their entire length upon the rollers; and whilst the tube-plate holes may sometimes be of size to enable the mandrel to be driven in so far, yet it can only in few cases be so.

Dudgeon's expander, although for a year or two now pretty largely used, must, we are disposed to think, give place to another form of expanding instrument introduced by Mr. Thomsom, engineer, of Glasgow; and although only a few months before the public, this instrument has been made and sold in very large numbers.

Like Dudgeon's instrument, Thomson's also consists of a central cone and surrounding rollers, Dudgeon's being *parallel*, whilst Thomson's are truncated cones. In Thomson's expander the taper of the roller lies opposed in direction to the taper of the mandrel, and the ratio of taper on each being equal, necessarily insures that points in the circumference of the rollers lie parallel to each other; thus producing a parallel expansion of the end of the tube so as to thoroughly fill the hole in the tube-plate. Thomson's expander being the most recent, we have thought it desirable, in order to give additional clearness to our previous remarks, to illustrate by woodcuts.

The instrument is made in several forms, two of which are shown at figs. 1, 2, 3 and 4; figs. 1 and 2 being an elevation and plan of one arrangement, figs. 3 and 4 a vertical section and plan of another arrangement. In figs. 1 and 2 the expanding rollers *a* are held by circularly dove-tailed heads *b* in dove-tailed radially situated recesses *c* formed in the body A, so that they cannot fall or be pulled out. When that part of the instrument which secures the rollers *a* is placed within the end of the tube to be expanded, the nut B is tightened on the screw C against the head of the body A. This has the effect of drawing the large end of the central conic mandrel inwards, and it therefore presses out the rollers *a* against the interior of the tube. When they are thoroughly tightened so as to press the tube against the hole in the tube-plate, the whole instrument is rotated in the tube by applying a winch-handle or wrench to the required end *f* of the central spindle. When the expansion of the tube has been effected, the instrument is removed by loosening the nut B, thus allowing the central spindle to be pushed inwards, and therefore releasing the pressure on the cones. In the other form of the instrument, shown at figs. 3 and 4, the action is the same as in the preceding,

but the cones are held in place by the flexible steel or elastic ring *d*, which embraces recesses in their necks.

Instruments founded on similar construction to the expander have also been introduced by Mr. Thomson for cutting tubes, also for withdrawing both ferrules (when these are used), as well as the short pieces of tube from the tube-plate, without injuring the holes therein. The tube cutter is shown at fig. 5 in elevation, and at fig. 6 in

FIG. 1.

FIG. 3.

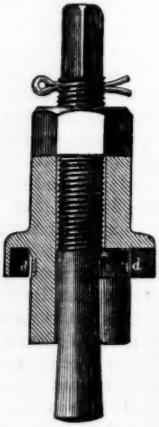


FIG. 5.

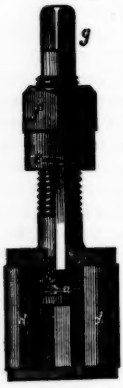


FIG. 2.

FIG 4.

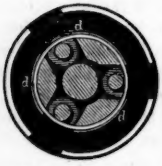


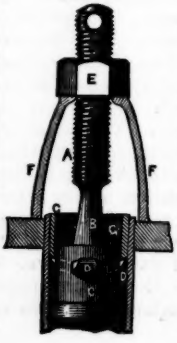
FIG. 6.

end view. The cutting disc *a* is carried on an axis in the carriage *b*, which is hinged by a bar to the body of the instrument at *c*. The body also carries rollers *d*, and in the center the taper guide *e*; and as the carriage *b* and the cutter *a* are forced downwards upon the guide *e* by the nut *f*, the cutting disc *a* is forced out against and into the metal of the tube to be cut. By turning the instrument round with a wrench applied at the squared end *g*, the disc *a* being forced out cuts an even indentation all round the interior of the tube, two or three revolutions being sufficient to cut ordinary boiler tubes completely through.

The tool for withdrawing ferrules or the cut-off ends of tubes from tube-plates is shown in elevation at fig. 7. It consists of a spindle A having a cone B formed at one end. A hollow cylinder C, fitted with a number of claws D, is fixed around the cone B, so that by tightening the nut E against the bridge F the cone B is drawn backwards; thus expanding the claws D so as to catch against the inner edge of the ferrule G, and by continuing to tighten the nuts E the ferule G is drawn out.

We have before merely hinted at one exceptional mode of securing boiler tubes, based upon the reverse foundations of what we have heretofore more especially considered; that is, the plan of M. Berendorf, of Paris, and which, we believe, has been pretty largely used by the firm of Cail & Co. of Paris. The plan consists in boring the tube-plates with holes of larger diameter than the tubes to be inserted; in the annular space which obtains around the tube when it is inserted, a double-coned ring is inserted; this, on being driven in, acts with its outward conical face, by filling the hole in the tube-plate, and the inward hollow cone becomes compressed around the tube end. Berendorf's plan is said, in certain cases, to have answered well, and we know that it is at present being looked upon attentively by boiler-making firms in the north. Our opinion of the method is that it may answer well for boilers not worked above a medium steam pressure, but it is quite evident that tubes when so fixed cannot act with nearly so much efficiency as stays, as when secured in the tube-plates by expansion outwards; and although the system may afford more facility in the removal and replacement of the tubes, which we fully admit, still it is quite clear that the heating surface of the boiler is reduced, on account of the space taken up by the rings preventing so large a number of tubes being inserted in any given dimensions of tube-plate.

FIG. 7.



When reviewing certain methods of fixing

tubes, in the foregoing part of this paper, we confined our remarks more especially to boiler-tubes. We now propose to consider what has been done to effect the same object in surface condensers.

The methods which have been at different times employed for fixing condenser-tubes may be divided into three general heads:

A. In which the packing used is metallic.

B. By means of fibrous packing.

C. By means of elastic media such as india-rubber.

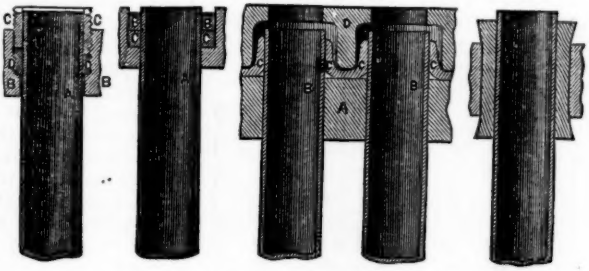
Method A was proposed and first used by James Watt for fixing the tubes of his surface condensers, which he at an early date used in preference to the injection condenser. We are not informed accurately (so far as we have been able to ascertain) as to the precise details of the method by which they were fixed, but as their upper and lower ends were secured in cast iron boxes, we imagine that they must have been expanded by drifting. Similar condensers, so far as we can learn, were constructed on the Clyde by Mr. David Napier, about 1820–21, and about the same period Brunel patented another form of condenser.

Very little importance was, however, achieved with the surface condenser until 1831, when Samuel Hall turned his attention to the subject, and eventually produced such excellent results.

His mode of fixing is shown at fig. 8, which is a longitudinal section of a tube A fixed in the condenser tube-plate B. The hole in the tube-plate B is recessed to a considerable depth, the recess forming an annular space surrounding the tube when in its place, and it is tapped so as to receive the short screwed ferrule C, which, being screwed down, compresses the ring of hemp D into the lower part of the recess. By this means the tube is not only very effectually held in the plate, but at the same time it is allowed to expand and contract freely without straining either the plate or itself, whilst, by merely withdrawing the ferrules at either end of the tube, and picking out the hemp packing, the tube is left free for removal. We must remember that this arrangement of Hall's was the first which was found practically successful. There is no record of a surface condenser having been successfully employed in a sea-going steamer at any previous date.

As we are not at present discussing the merits and construction of condensers themselves, but one particular detail only, next in order we find Spencer's method, shown at fig. 9. This consists in recessing the tube-plate around each tube A to the depth of .125 to .187 of an inch in width, and compressing into them two or more (but usually two) india-rubber rings B C, which are put in sufficiently tight to prevent leakage when the pressure is on the outside of the plate. Then follows Sewell's; it is shown at fig. 10. This plan of fixing condenser-tubes is perhaps the most complicated of any introduced. The tube B projects some distance beyond the tube-plate A; over these projecting portions a sheet of india-rubber, formed so as to fit over the whole of the tubes, is placed. This sheet is necessarily made in one entire piece, of the same size as the tube-plates, and in it holes are formed to correspond in pitch with that of the tubes; but the holes themselves are slightly less in diameter than the tubes, so that on being placed over them the india-rubber turns up in a cup-like form round the exposed ends, as shown. Over the india-rubber sheet is an outer plate D perforated to correspond with the tubes; it is recessed, as shown, so as to pass over the tubes and surround the india-rubber cups, at the same time leaving room for the tubes to expand and contract freely when the plates are screwed together. The diameter of the holes in the outer or covering-plate is nearly the same as the interior caliber of the tubes themselves, and it serves two purposes, namely, of keeping the india-rubber sheet close against and on the ends of the tubes, at the same time preventing the tubes from

Fig. 8. Fig. 9. Fig. 10. Fig. 11.



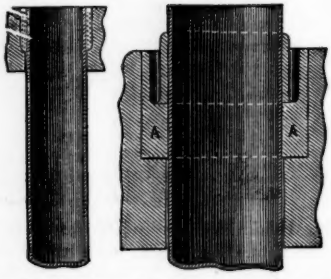
working out of the plates. This method, although the most expensive, has, we believe, been pretty largely adopted of late years, but we know that some engineers do not think favorably of it.

Allen's method is shown at fig. 11; it consists merely in inserting a wooden ferrule A into an annular space in the tube-plate which surrounds the tube; this, on being driven in, becomes compressed, thereby filling the hole, and at the same time firmly holding upon the tube; but before being put in, the ferrules are first squeezed in a compressing machine.

Howden's method is shown at fig. 12. In this case the hole for receiving the tube is reduced to a depth equal to about three-fourths of the thickness of the tube-plate, and into it a short length of plaited cord is compressed, the cord being very easily and quickly inserted by means of a tool revolved in the recess by a hand-brace; this system is, perhaps, the cheapest and simplest yet devised, and is, we understand, coming into use on board of several steamers.

The last, and, so far as we can learn, a very effectual method of fixing condenser-

Fig. 12. Fig 13.



tubes is that introduced within the last few months by Marshall, of Leith; it is shown at fig. 13. In this example the recess surrounding the tube is filled with an india-rubber ring A, which ring has a deep annular space formed in it, into which the water passes, having the effect of forcing the outer lip of the ring against the tube-plate, and the inner lip against the tube, thereby constituting an effective joint on both sides. Marshall's plan is being already introduced on the Clyde as well as at Leith, and the North British Rubber Company have commenced the manufacture of the rings.

We have now brought together all the more important modes of fixing surface condenser tubes, and as we shall on a future occasion probably refer at length to surface condensers themselves, we reserve further remarks on the subject at present.—V. D.

The Flow of Elastic Fluids through Orifices or Pipes.—In order to determine the number of cubic feet of steam or air, or other gas, which will be discharged through a given orifice in a given time, it is necessary to ascertain the velocity of issue. In no other way can the problem be solved, except by experiments with vessels of known capacity, from one of which the air, steam, or gas flows to the other. Such a solution is, for reasons on which it is not necessary to enter, practically beyond the reach of most men; and it has already been tried by many, with results which have enabled a general law to be laid down, to which law we shall come presently. If the velocity is known all the rest follows easily enough. Let us suppose the orifice in the side of a boiler to be one inch square. A cubic foot of steam contains 1,728 cubic inches. We may suppose this cubic foot of steam all contained in a column or bar 1,728 in. long and 1 in. square. Let one end of this bar be brought opposite the orifice and the work of expulsion begun; then it is obvious that before the whole cubic foot of steam is discharged, a column of steam 1,728 in. long must be passed through the hole. Now, if the velocity of efflux is 1,728 in. per minute, then one minute of time will be required for the escape of one foot of steam. If it have a velocity of efflux of 1,728 ft. per second, then the orifice will discharge one cubic foot per second, and so on. And this law is totally independent of the pressure or weight of the steam. As the pressure increases, the *velocity* of discharge will increase in a certain ratio to be presently explained; but the pressure will not affect the fact that the *velocity of discharge in inches per second*, multiplied by the area of the orifice in square inches, and divided by 1,728, will give the discharge in cubic fees per second.*

We have said that the velocity is regulated by the pressure, but this fact only holds good for each particular fluid. Speaking

* When a discharge of water, steam, gas, or other liquid or fluid takes place through an orifice in a thin plate, a certain contraction takes place in the issuing column which reduces the amount of discharge below that proper to the actual area of the orifice, but it is needless to do more than mention the fact here. It is quite unnecessary to complicate a statement which we wish to make as simple as possible, by further reference to the *Vena Contracta*.

comprehensively, the velocity of discharge depends on the density as well as the pressure of the fluid; the lighter the fluid the greater will be the discharge. Thus, hydrogen will issue more rapidly under a given pressure through a given orifice than will atmospheric air under the same conditions of pressure and orifice. If our readers have followed us thus far, they will be able to comprehend the nature of the law determining the velocity of discharge under given conditions of orifice and pressure. But before giving this law it may be as well to explain, that any body falling freely under the influence of gravity has a progressively accelerated rate; the velocity being in England and similar latitudes such that 16 ft. 1 in. will be traversed the first second, 48 ft. 3 in. in the next second, 80 ft. 5 in. in the third second, and so on. The velocity of a falling body at any distance from the point where it started, may be found by multiplying the square root of the height passed through in feet by $8\frac{1}{24}$, the product being the velocity in feet per second. Thus, a bullet has been suffered to drop from the top of a tower 100 ft. high; what is its velocity at the moment of touching the ground? The square root of 100 is 10, and 10 multiplied by $8\frac{1}{24}$ gives 80.042 ft. as the velocity. Our non-mathematical readers will now be in a position to understand the law regulating the velocity of efflux of elastic fluids, such as steam, under pressure, which may be thus stated: *Elastic fluid flow into a vacuum with a velocity the same as that which a body of the same density would acquire in falling through a space equal to the height of a column of steam or gas of the given pressure.* Let us suppose that we are dealing with steam of 45 lbs. on the square inch, and the orifice of discharge has one square inch of area. Let us further suppose that a column of steam stands on a valve temporarily closing the orifice. What height must the column of steam one inch square be to weigh 45 lbs.? Avoiding fractions, nine cubic feet of such steam will weigh 1 lb.; therefore, our column of steam one inch square must contain 9×45, or 405 cubic feet of steam; and multiplying 405 by 1,728, we get 699,840 as the height in inches, or 58,320 as the height in feet of our column of steam.* The square root of 58,320 is 241.5 nearly, and this multiplied by $8\frac{1}{24}$, or 8.042, gives 1,942.14 ft. per minute as the velocity with which steam of 45 lbs. pressure would issue into a vacuum.

It is here necessary to explain that to avoid the introduction of a multiplicity of figures, we have omitted several fraction, and, therefore, the velocity we have given above is too low, but this in no way affects the principle of the arithmetical process we have described. Any of our readers mastering it will be able to calculate for themselves the velocity with which elastic fluids flow into a vacuum. The calculation, as we have worked it out, is, however, laborious, and for the benefit of such of our readers as understand logarithms, we give the following comprehensive rule for finding the velocity of discharge: Add 4.29 to the pressure in pounds per square inch; deduct the logarithm of this sum from the logarithm of the pressure; to one half the remainder add 3.3254, and the natural number of this sum will be the velocity in feet per second.† The difference between the velocities due to any two pressures is the velocity with which steam or air will flow into the lower pressure. Thus, if the pressure in a cylinder is 20 lbs., while that in the condenser is 5 lbs., at what rate will the steam flow from the former to the latter? The velocity proper to steam of 5 lbs. pressure is 1,552 ft. per second, while that proper to 20 lbs. is 1,919, and 1,919—1,552 gives 367 ft. per second as the velocity of the exhaust.‡

In the earlier portion of this article we stated that the actual area of the column of discharge was less than that of the orifice through which it flowed, and it is now time to say that this fact materially modifies the results of such calculations as the foregoing. Moreover, account must be taken of the frictional resistance due to the sides of pipes or tubes through which the fluid flows. On this latter subject there is considerable diversity of opinion; the subject has been keenly discussed once in our correspondence columns, and we shall not be surprised if it be discussed again. Meanwhile we cannot better conclude this article than with the following rule, extracted from "Bourne's Treatise on the Steam Engine," and regarded by many engineers as one of the best yet made on the subject. It refers to the flow of steam through a straight pipe of uniform diameter, and its relation to the

* This is an approximation only. The true volume of 1 lb. of steam at 45 lbs. total pressure is 9.000216 cubic feet.

† Sewell.

‡ These velocities have been calculated by the last rule.

rules we have laid down will be readily traced: "To the temperature of the steam in degrees Fah. add the constant 459, and multiply the square root of the sum by 60. 2143; the product is the required velocity." All enlargements and contractions, and all bends or elbows, will reduce the velocity, but there is no trustworthy formula in existence which will enable us to determine exactly how much in any of the particular cases which may suggest themselves to our readers."—*The Engineer.*

BIRMINGHAM.—None, caring to trace the growth of the "work-shop of the world," need necessarily go back to the time, less than a hundred years ago, when letters were addressed "Birmingham," (or, often, Bromwicham), near Walsall," the latter being the nearest post town. The population of Birmingham, now upwards of 350,000, has doubled since 1841, and is five times what it was at the beginning of the century. Even those who have never been within a hundred miles of the place, know the general nature of its manufactures, but few are aware how these have increased in extent and variety of production. Almost exclusively a manufacturing town, Birmingham may nevertheless be said to have no cotton, woolen, flax, or silk factories, no blast furnaces or forges, no steel converting works, no work-shops for making locomotives, engineers' tools or textile machinery, no sugar refineries, paper mills, tanneries, breweries (except upon a small scale), in fact, none of those great distinctive industries which make Manchester, Leeds, Sheffield, and, in a less degree, Newcastle, Glasgow, Bristol, and other great manufacturing towns, what they are.

But there are large factories in Birmingham, where hundreds of work-people are employed in making pins, steel pens, umbrella tips, tacks, indeed the smallest articles in the largest (or, at least, in bewildering) numbers. Steel pens, for example, which once cost a shilling each, are now sold, and of far better quality, for a shilling a gross, and, of these, single establishments make from 200 to 300 millions each yearly. These are the *minutiæ* of manufactures, but there is a single establishment employing a thousand work-people, which produces a thousand million of wood screws yearly. Nearly as large a number are employed, at a single factory, in making bolts and nuts, and, besides these, iron hoops for cotton bales. And in the pen factories, including Gillott's and Mason's, in Nettlefold and Chamberlain's great screw factory, at the works of the Patent Nut and Bolt Company —nearly everything is done by machinery. The immense stride made in the manufacture of Birmingham goods during the last comparatively few years has been due to the introduction of machinery, worked in large factories, under perfect organization; whereas, previously, masters let out metals, or part-worked goods, to work-people who took them home and completed them by hand. The Birmingham gun trade was revolutionized by the erection of the immense small arms factory at Small-heath, which contains the most perfect gun-making machinery of the Enfield kind.

Of Birmingham buttons, gold and "brummagem" jewelery, nondescript hardware and knick-knacks, we cannot pretend to speak with knowledge. But turning to the larger industries, there are the historical engine works at Soho, besides smaller engine works in town; the very extensive railway carriage works of the Metropolitan Railway Carriage Company at Saltley, and Messrs. Brown, Marshall and Co.'s railway carriage works in the vicinity; Messrs. Chance Brothers' great glass works, Winfield's large establishment for making iron bedsteads and brass work, Everitt's, Webster and Horsfall's, and Cornforth's wire mills, Elkington's magnificent electro-plate works, Muntz's yellow metal works, Lloyd's and the Imperial tube works, the Stephenson copper and brass tube and roller works, Tangye's and May's engine and machine works, Morewood's galvanizing works, Piggott's and Horton's gasholder works, etc., besides the old copper mint at Soho, enameling works, manufactories of *papier maché*, swords, files, etc., all representing distinct industries, in each of which, perhaps, two or three, or in other cases forty or fifty establishments are engaged.

It is not, perhaps, to be lamented that Birmingham no longer produces those great works of engineering construction which she once did in the days of Fox, Henderson & Co. Their old works, the London Works, now the property of the Patent Nut and Bolt Company, turned out all the ironworks of the Crystal Palace of 1851, the great station at Birmingham, still the largest, under one roof of a single span, in the world, the Paddington Station, and the

great suspension bridge over the Dneiper, at Kiev, in Russia, probably the finest individual work of its engineer, Mr. Charles Vignoles.

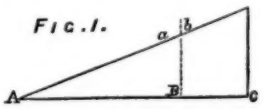
Birmingham is a little too far from a sea port for the cheapest transit of heavy manufactures intended for shipment abroad, but its railway and canal facilities for inland communication are unexcelled. It is a healthy town, on elevated, gravelly, or sandy soil; the latter, when in its natural state, growing a profusion of broom (Saxon *brum*, whence the name of the town), and the death-rate is much lower than in Manchester, Leeds, Sheffield, or Liverpool. There are few underground habitations—cellars—and one man in Birmingham occupies as much ground as two in Manchester, or three in Liverpool. It is only a wonder that so wide-stretching a town has not long since been tramwayed in all directions, a fact only accounted for, perhaps, by its local railway facilities. Nor is it easy to understand why some of the heavier branches of forging, steel melting, wheel making, locomotive engine building, etc., should not have yet settled there, unless it is that the business is overdone, or that Staffordshire iron, so well known for its good quality, is somewhat more cheaply worked up elsewhere.—*Engineering.*

THE MEASUREMENT OF HILLS.

From the "Building News."

It is seldom, that a base line of any considerable length can be measured without it being necessary to make some allowance, either mechanically or by calculation, for the sloping and irregular contours of the ground. The necessity for this becomes more apparent as the surface of the ground departs from the plane of horizontality, as the greater the angle of inclination the greater will be the difference between the false and the true, or the inclined and horizontal measurement. There are various methods of arriving, at the true horizontal measurement of sloping surfaces, and the degree of accuracy to which the survey is to be carried, must in all cases determine which the surveyor will employ. It is scarcely necessary to mention that the true distance will always be less than the apparent one, and, therefore, when calculation is used, there will always be a reduction to be made. An experienced surveyor will be able to tell pretty well by the eye the allowance to be made in the majority of instances when only approximate accuracy is demanded, and the question becomes reduced to taking the next measurement or chain's

FIG. 1.

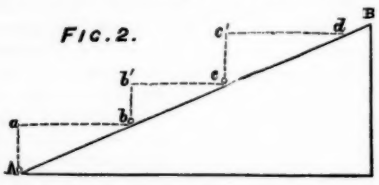


length, not from the end of the former, but from a point obtained by making the proper allowance. The diagram in fig. 1 will render this operation perfectly clear, but it is one that the young surveyor will do better not to attempt to carry into practice. We shall give a method by which the same result can be arrived at by means more suitable for a beginner. In fig. 1, suppose the chain to be stretched upon the inclined surface of a hill and extend from A to *a*, but the real horizontal measurement to extend from A to B. The point B where the chain A *a* will intersect the horizontal is found by taking A *a* in the compasses and sweeping a circle until it touches the horizontal line A C in B. If the line B *b* be projected at right angles to A C it will intersect the surface of the ground at *b*, so that the true distance to be measured along the slope by one chain's length, is not A *a*, but A *b*. From the appearance of the slope the practiced surveyor makes an approximate estimate of the distance *a b*, and the next chain's length is measured consequently not from *a* but from the point *b*, and so on, as often as may be required. The same process applies to the case of a descent as well as that of an ascent, but it is rather curious that it is invariably more difficult to arrive at a correct approximation of the rate of inclination when descending than ascending a slope. We do not attempt to offer any explanation of this somewhat curious fact, but our own experience, as well as that of numerous old and practiced hands, have confirmed the veracity of it.

The explanation of the method by which the distance *a b* in fig. 1 is estimated, will serve to indicate a mechanical mode of arriving at the same result. This latter is preferable, when carefully performed, to that given in fig. 1, and may, moreover, be accomplished by any beginner. It should not, at the same time, be repeated too often consecutively, as of course, small errors creep in at every step, which ultimately would become seriously appreciable. Let A B in fig. 2 be the sloping ground to be measured horizontally. In performing this operation we

advise the surveyor to do part of the chaining himself, that is, to take the place of the "follower." If he leaves it to the chainmen to do, he may be sure that it will not be done well, as it is an operation requiring some nice and delicate manipulation. Briefly, the principle consists in taking up the chain in short lengths and holding one end vertically over the starting points, while the other

FIG. 2.



is fixed or held firmly down. In the figure let the surveyor be supposed to stand at A, with the end of the chain held vertically over the point A, by means of a plumb line and bob. In the meantime the "leader" has hold of the twenty-fifth link, suppose, which he fastens down in the proper direction at *b*; the surveyor then slacks the end of the chain, advances to the point *b*, takes up the chain carefully at the twenty-fifth link, leaving the pin in to mark the spot, and holds it over the point *b*, or, in technical phraseology, "plumbs" it over the point *b*. The "leader" has advanced to the fiftieth link, which he has fixed at *c*, and the operation proceeds in a similar manner to *d*, and until the summit of the incline is surmounted. The chain must be well stretched between the points at *b'c*, *c'd*, etc., in order to render the deflection inappreciable, so that it is preferable to take short lengths at a time, instead of long ones, although the former may demand more trouble. The steepness of the slope will also regulate the distance between the successive points of measurement, as the chain can only be raised a certain height by hand, and it is absolutely necessary that it be maintained as nearly horizontal as the circumstances of the case will allow. If this mechanical reduction of the inclined to the horizontal measurement be carefully performed, the result will be a very close approximation to the true distance. In order to get over the ground as quickly as possible, young surveyors are very apt to make the distances between the points of measurement much too long, and consequently the "sag" of the chain induces errors that might otherwise be avoided with facility. Should the hill be very short, the incline may be measured very expeditiously in the manner described by means of a good tape, provided there is very little wind blowing.

Having described the two approximate methods of reducing the sloping to the horizontal measurement, it now remains to indicate the more exact means of obtaining the same result. It is hardly necessary to observe that in large and important national and trigonometrical surveys approximate methods cannot be employed, but all the operations must be performed with the most minute accuracy. A glance at at fig. 1 will point out that there are three sides in the triangle A *b* B, one only of which is known. By the rules of proportion, as well as of equations, when one of these indeterminate quantities is to be determined, two must be given in order to solve the question. In the triangle A *b* B, the distance A *b* is given and if B *b* were known, the horizontal distance could be ascertained, since $(A\,b)^2 = (A\,B)^2 + (B\,b)^2$, or making A $b = x$; A B $= y$, and B $= z$, we have for the value of A B, $y = \sqrt{(x^2 - z^2)}$. But B *b* is the difference of level between the points A and *b*, which can be readily obtained by that branch of surveying which treats of the operations of leveling. As this will be subsequently treated of in its proper place we shall not now enter further into the question. It will be manifest that if instead of the distance B *b* being known, the angle of inclination or the angle B A *b* were ascertained, the problem could be solved equally readily. Suppose, for instance, a certain number of feet were measured along the slope in fig. 1, from A to B, the correct horizontal measurement of which was A B, but which has to be determined; let A B $= N'$, A $b = N$, and Θ equal the angle of elevation B A *b*. By the rules of trigonometry for solving right-angle triangles we have $N' = N \times \text{cosine } \Theta$, consequently the difference between the horizontal and the sloping measurement varies as the cosine of the angle of elevation, or, in plain terms, with the slope of the ground. The difference between these two measurements, or what is called the "reduction," is evidently equal to $(N - N')$. As an example, suppose N or the distance A *b* in fig. 1 to measure 100 ft., and the angle B A *b* 15°, what is the value of the correct horizontal measurement A B, and of the reduction $(N - N')$? By the rule we have A B $=$ A *b* $\times$ cosine $15° = 100 \times 0.96592 = 96.592$ ft. The reduction, therefore, is equal to $(100 - 0.96592) = 3.408$ ft. The correct distance to be entered in the field book from A to *b* is 96.592 ft., but if

there is no necessity for noting the point b' on the plan, the simplest method will be to add 3.408 ft. to the 100 ft. already measured, and commence the next chain's length from that point. In other words, 100 ft. on the horizontal measurement equals 103.408 ft. on the sloping surface. From the formula and example we have given, it is readily perceived that tables can be constructed giving the reduction to be made, or the difference between the horizontal and sloping measurement for different angles of inclination. In the following table is shown the number of feet on a sloping surface inclined at various angles that corresponds horizontally to 100 ft. measured along the given slope, and also the reduction to be made for every chain's length or 100 ft. measured along the slope:

Angle of slope in degrees.	Value of 100 ft. measured horizontally.	Difference or reduction.
3	99.862	.138
6	99.452	.548
7	99.254	.746
10	98.480	1.520
12	97.814	2.186
14	97.029	2.971
16	96.126	3.874
18	95.105	4.895
20	93.969	6.031
23	92.050	7.950
27	89.100	10.900
30	86.602	13.398

If the slope continue uniform, and there are not any fences or other objects to be noted in the field book, the chaining can be continued as far as may be considered desirable, and the results in the third column given in the table multiplied by the number of chains measured. The product will give the total reduction or difference to be allowed for.

THE ELLERSHAUSEN PROCESS.—We have not yet received the analyses, complete, that we promised to publish. But we are prepared to state, from the results of other and more extended experiments, that this process is highly successful and valuable. It is not so radical and revolutionary as at first supposed, but it is a decided improvement upon a preparatory process in puddling, the results being an improvement in the quality of the product, and a decided and uniform economy in its production. We shall give details in due time.

HEATING BUILDINGS BY GAS.

From "The Engineer."

The use of gas as fuel has been tried to a considerable extent in France and other countries, but the progress has neither been rapid nor very satisfactory; one reason of this lies, perhaps, in the imperfection of the modes of combustion, although something has been done of late to remedy this; another is the natural hesitation of the directors of gas works to keep pressure on their gasometers all day for a small supply.

Still enough has been done to supply a certain amount of information on the economical part of the question, both as regards gas cooking apparatus and stoves for churches and other large buildings. The average consumption of the cooking stoves in use in France which consume a mixture of gas and air is found to be as follows:—For a large fire, 260 liters per hour; for a moderate fire, 140 liters per hour; for a small fire, 50 liters per hour. When the stove is used, what the French call *pot-au-feu*, it is found that it is sufficient to keep up a large fire for about twenty minutes only, after which the gas may be turned down and the cooking completed with a very small fire. Taking the average duration of this kind of cooking at four hours, and the cost of gas at 30c. per cubic meter—the present price in Paris—the consumption amounts to 1,040.20 liters, the expense of which is 31c. 20, or little more than 14d. The cleanliness and handiness of gas as fuel, and the great economy arising from its instantaneous lighting and extinction, give it, *in the hands of careful persons*, a great advantage over charcoal, with few of its inconveniences—one of which is the impossibility of using it for broiling without a special arrangement, as the smallest quantity of fat falling upon heated charcoal fills the house with stifling fumes.

In a coal-using country, however, like England, the use of gas for the heating of apartments, and especially large buildings like churches, is of more importance than its application to cooking; and considerable improvement has been made of late in France in apparatus for the warming of ordinary rooms, to which we shall shortly have to refer more particularly.

The most important results yet produced refer to the heating of churches, which has been essayed on a large scale at Berlin. The method generally adopted is that of placing a horizontal gas-pipe with three jets

within a stove made of sheet iron, and over the gas-jets a piece of brass wirework, of which the openings are not more than $\frac{1}{25}$ of an inch in diameter. The cathedral of Berlin has a cubical contents of about 17,300 meters, and it is heated by means of eight of these stoves, each of which has 22 of these brass gratings, measuring $11\frac{1}{2}$ in. in length by $1\frac{1}{2}$ in. in width, making in all about half an inch square of grating for each cubic meter to be warmed. The consumption of gas in raising the air within the edifice to the required temperature—an operation which takes three hours—is 83,400 liters, or 4.82 liters per cubic meter; to maintain the same heat afterwards requires only $\frac{7}{10}$ of a liter of gas per cubic meter.

The parish church of Berlin, whose cubic contents is 13,800 meters, is heated by four stoves, each having 15 brass gratings, each rather more than 12 in. long by $1\frac{1}{2}$ in. wide, or little more than $\frac{1}{5}$ of an inch of grating per cubic meter to be warmed. The annual consumption of gas in the cathedral above mentioned is 2,210 cubic meters, costing £20; this consumption is equal to 552 meters per stove, and 300 liters per $\frac{2}{5}$ of an inch square of grating. The consumption in Parisian churches warmed by gas is found to agree very closely with that of the cathedral of Berlin, but other cases give different results:

The church of St. Philippe at Berlin has a contents of 2,780 meters, and is heated by two stoves 1m. 40 high, 1 m. 10 long, and 65 centimeters in width. each having seven brass gratings 16 in. by 2 in., equal to $\frac{2}{3}$ of an inch square per cubic meter of the contents of the church. The annual consumption in this church is 1,485 cubic meters, or at the rate of 410 liters of gas per cubic meter of contents. But this church is only warmed three times a week.

The church of Saint Catherine at Hamburgh is heated by eight gas stoves, each having 32 brass gratings, 12 in. long by rather more than $1\frac{1}{2}$ in. wide; the cubic contents of the edifice is 33,900 meters. The heating takes three hours and a half, and consumes 220 meters of gas, costing about 27s. 6d., so that three liters of gas are required in this church per cubic meter of capacity; the temperature is kept up subsequently by the consumption of $\frac{3}{4}$ of a liter per cubic meter and per hour.

In the churches of St. Mary and Nicholas in Berlin, and in Paris also, a kind of large rose burner has been substituted for the brass grating; these are known in France as mushroom burners (*champignons*). The result with these burners in the first of the above named churches is as follows: The cubical contents of the building is 15,450 meters, and the consumption of gas in four hours is 150 cubic meters, costing about 35s., and as it is heated by ten stoves, each having three of these rose burners, the consumption per hour is $1\frac{1}{2}$ cubic meters of gas per burner, and nearly $2\frac{1}{2}$ meters for each meter of the contents of the church. In this case only we have the effect as shown by the thermometer, which is to raise the temperature of the church from one degree below zero to five degrees above, or from below thirty degrees to forty degrees Fah.

In heating churches and large buildings the economy of gas exhibits itself quite differently as compared with its application to cooking; in the former case, the more continuous the operation the less the relative cost, whereas in the latter the more frequent the interruptions the greater the economy. The objection to gas on account of its vitiation of the atmosphere of a building is one which neither the wire grating nor the mushroom burner has yet obviated.

DETERMINING THE POWER OF ENGINES.

By J. Deby, C. E.

From the "American Artisan."

Many rules are furnished in all treatises on the steam-engine for determining the horse-power, nominal or indicated, but none of them presents that scientific accuracy which alone gives real value to the results of experiments. The steam-engine (including its boiler, which is an intrinsic portion of itself) is nothing but a converter of heat into mechanical work; and consequently, in a general way, that engine which will approach the nearest to producing a maximum effect from a given quantity of fuel must be considered the best.

We know that a certain amount of any kind of fuel can only convert a certain determined quantity of water into steam of a given pressure, and we further know that this steam ought, theoretically, to do a certain amount of work. Starting from this basis, we can solve the problem without any great difficulty.

The first thing we have to do is to find out the exact composition of the fuel used. This is the duty of the analytical chemist,

who tells us how much carbon, hydrogen, oxygen, ashes, etc., are contained in it. The carbon and hydrogen are alone the producers of heat, and all the other substances are absorbers of heat, and worse than valueless. Knowing the composition by weight of one pound of the fuel, if we multiply the amount of carbon contained in it by 8,000, and add to this product the amount of hydrogen multiplied by 36,000 (the units of heat evolved respectively during the combustion of one pound of carbon and of hydrogen), and then subtract therefrom the quantity of oxygen in the fuel, multiplied by 3,000, we obtain very approximately the total number of units of heat given out during the combustion of one pound of the fuel.*

If we divide this total number of units of heat given out by one pound of the fuel by the total number of units of heat contained in one pound of steam of the given tension (for which see tables or formula in the books), we obtain the number of pounds of water which might be converted into steam by one pound of such fuel in a *theoretically perfect* boiler. By carefully comparing the weight of water really evaporated in practice with the amount of fuel consumed for the purpose, we have thus an easy method furnished us for determining the efficiency of the boiler, fire-box, dampers, flues, etc.†

When we know by direct measurement how many pounds of water have practically been evaporated in our boiler by the combustion of one pound of fuel, if we multiply this quantity by the total number of units of heat contained in one pound of steam of the given tension, we find the total amount of units of heat which have been transmitted to the engine for the purpose of producing useful work. Multiplying this number by 2,000, the mechanical equivalent of a unit of heat, we obtain the number of foot-pounds of mechanical work which this amount of steam ought to produce if the engine were *theoretically perfect*.

Noting the number of foot-pounds thus developed in the space of one minute, and dividing this quantity by 33,000, we obtain the theoretical horse-power which would be derived from a *theoretically perfect* engine.

By comparing the horse-power of an engine, as exhibited by the indicator, with the theoretical figure obtained by the method we have just exhibited, it becomes very easy to compute how near to, or rather how far from, perfection any particular steam-engine may prove to be. In the absence of an indicator, the "actual" horse-power may be determined by the ordinary formula for "indicated" horse-power, when the strokes per minute, length of stroke, and area of piston are known.

Let us give an example:

Supposing one pound of the fuel consumed to be formed of .92 of carbon, .63 of hydrogen, and .03 of oxygen, its calorific power would be $(.92\times8{,}000)+(.03\times36{,}000)-(.03\times3{,}000)=8{,}350$ centig. units. If the engine is working steam of four atmospheres, or 59 lbs. to the square inch, each pound of steam will require for its production 651.8 units of heat, minus the temperature of the feed-water, which we will suppose in our case to be 51.8° centigrade, leaving 600 centigrade units of heat to be obtained from the fuel.

Dividing 8,350 by 600, we have 13.91 as the number of pounds of water which one pound of such a fuel could evaporate, *as a maximum*, into steam of four atmospheres. Now, if in our practical experiment one pound of fuel has only evaporated 10 lbs. of water, we see that a loss of 3.91 lbs. has taken place, equal to 39 per cent of the fuel used. *This first loss must have taken place through inefficiency in the boiler or its surroundings.* The 10 lbs. of steam of four atmospheres produced, contain $10\times651.8=6{,}518$ units of heat. Each of these units is the equivalent of 2,000 foot-pounds of mechanical work, and the 6,518 are equal to $6{,}518\times2{,}000=13{,}036{,}000$ of foot-pounds. If the 10 lbs. of water have been evaporated in 13 minutes, then $13{,}000{,}000\div13$, or 1,000,000 of foot-pounds will have been produced per minute, which, divided by 33,000, gives us 30 horse-power as the duty of a *theoretically perfect* engine. If, in our case, 20 horse-power only has been "indicated," then a 10 horse-power, or 33.4 per cent, would be shown to have been *lost in the engine alone* through friction, radiation, or from other causes.

In our example, 39 per cent of heat would have been lost in or around the boiler, and 33.4 per cent by the engine, showing a total loss of 72.4 per cent of the fuel burnt on the grates. Our experimental engine might

* The exact calorific values of bodies vary somewhat, according to the results of different experimenters. Those we give here are the determinations of Scheerer.

† Care must be taken, if the boiler primes, to make the necessary allowance for unconverted water suspended in the steam.

be said to be 72.4 per cent from perfection, and, in like manner, all kinds and sizes of steam-engines and their boilers may be rationally and simply classified and rated.

DRIED WOOD FOR BLAST-FURNACE FUEL.

By MARTIN MOSCHITZ, Royal Hungarian Counsellor of Mines.

Condensed and translated from "Oestr. Zeitschrift."

For a number of years it was intended to try, on a large scale, the use of dried wood in the place of charcoal in the blast-furnaces at Rhonitz, in Hungary. In 1862, all the necessary preparatory arrangements were completed, and the gradual replacement of 3, 5, 10, 15, etc., per cent of charcoal by dried wood then began. This had to be done very slowly and carefully, as the local circumstances did not allow of any interruption or disturbance of the regular working order. From this reason the increase of the percentage of wood had sometimes to be stopped entirely for long periods. However, these experiments were so successful that, from the beginning of the year 1866, the two blast-furnaces at Rhonitz have been running *exclusively* with wood, a result more favorable than was or could have been expected from the start.

In the period from 1862 to 1868, the furnace No. 1 was running during 331, the furnace No. 2 during 231 weeks, the fuel used being partly charcoal alone, partly charcoal and wood mixed, partly wood alone. The amount of materials melted were:

581,657 cwt. (Austrian) ankerites, poor spathic ores, and brown hematites.
371,832 cwt. granulated cinder from puddling and heating-furnaces.
296,917 cwt. calcarious and dolomitic fluxes.

1,250,406 cwt.

The fuel used amounted in that period to
4,981,974 c. ft. (Austrian) of soft charcoal (including 10 per cent loss).
4,709,899 massive c. ft. of pine wood.

The products obtained were
294,760 cwt. gray forge-pig.
71,700 cwt. castings.

366,460 cwt.

The percentage of iron in the mixture for forge-pig was 38.45, that in the mixture for foundry-pig 29.30. The charcoal weighed about 7 lbs. per cubic foot; some of it less. From 40 to 64 per cent of charcoal, by volume, have been obtained from the wood by charring, or 19.08 per cent by weight.

To be able to compare the amount of fuel used when the furnaces were run with wood, to the amount used when they were run with mixed fuel or with charcoal alone, it is necessary to convert, in the calculations, all the wood used into the corresponding weights of charcoal. It has thus been found that the amount of charcoal used for the production of 100 lbs. of pig-iron has been, on the average, as follows:

(*a*) In smelting with charcoal alone..		195.09 lbs.
(*b*) In using 13.58 c. ft. of soft charcoal	95.06 lbs.	
and 12.84 massive cubic ft. of wood, weighing 31 lbs. per c. ft., the corresponding weight of charcoal is $\frac{12.84 \times 31 \times 19.08}{100}$ ...	75.95 lbs.	
		171.01 lbs.
(*c*) In using wood alone (since 1866):		
1. During the first 25 weeks were used 28.66 massive cubic feet of wood, the corresponding weight of charcoal is— $\frac{28.66 \times 31 \times 19.06}{100}$ ..... =		169.52 lbs.
2. All the rest of the time, up to this day, 27.02 massive cubic feet of wood the corresponding weight of charcoal..... =		159.82 lbs.

It is to be seen, from this statement, that by using wood instead of charcoal a saving of fuel is effected, amounting to (195.09 less 159.82) = 35.27 lbs. or 5.71 cubic ft. of charcoal, or 5.93 massive cubic ft. of wood, on 100 lbs. of iron produced. This is an actual saving of 18 per cent of fuel.

One pound of charcoal costs, at Rhonitz, .81 kreutzers (Austrian). [1 Austr. kreutzer is equal to about $\frac{1}{2}$ cent in gold. 1 florin = 48$\frac{1}{2}$ cents gold = 100 kreutzers.]

One massive cubic foot of wood costs	3.9 kreutzers.
Transport, cutting and drying.....	.8 "
Total cost of one massive cub. ft. of wood ready for use at the furnace,	4.7 "

From these data the saving in money, effected on 100 lbs. of pig, is calculated thus:

195.09 lbs of charcoal at .81 kreutzers = 1 florin.....	58.02 kreutzers.
27.02 massive cubic ft. of wood at 4.72 kreutzers = 1 florin.....	27.53 "
Leaving per 100 lbs. of pig.....	30.49 "

As the cost of 100 lbs. of pig amounts to about 2 florins and 30 kreutzers, the above saving corresponds to 13.2 per cent in money. This saving is, of course, the more considerable the higher the price of charcoal stands, when compared to that of wood. Fifty per cent of granulated puddling and heating cinders in the mixture are easily reduced and melted when dried wood is used as fuel.

The bast-furnaces in which the above results have been obtained are 42 ft. high, 3¾ ft. wide at the bottom, 12 to 13 ft. in the boshes, and 6 ft. at the top. They are shaped like the "blanofen" in which the Prussian spiegeleisen is made, the boshes running clear down to the bottom of the furnace in one steep incline. The mantel is carried by six cast-iron columns. The top is shut by a movable cover. Each furnace has four twyers into which the nozzles of the blast-pipes are fitted in tight. The nozzles are 2⅛ in. in diameter. The blast has a pressure of 1½ to 2 in. of mercury, and a temperature of 400° to 480° Fahr.

The gases are caught by a cylinder reaching 3 ft. into the mouth of the furnace. The circular space between the cylinder and the wall of the furnace is covered by a cast-iron plate with seven round openings equally distributed, through which the gases escape into seven vertical pipes all ending above in a horizontal circular pipe. Another pipe of sheet-iron, provided with a valve, communicates with the latter, and carries the gases to the places where they are wanted. The circular pipe has seven round openings above, situated in the prolongations of the seven vertical pipes mentioned. These openings, with short additional pipes cast on, are covered slightly by sheet-iron caps, which, like safety-valves, prevent the destructive effects of explosions. They also serve for the cleaning of the apparatus, and can be used to let the superfluous gases escape. The cylinder in the mouth of the furnace is necessary to prevent the atmospheric air, and the steam developed from the charged materials, from entering the gas-pipes. The sheet-iron main pipe carries the gases down 47 ft. to the general working level, and afterwards to a horizontal distance of 156 ft.

The cutting and the chopping of the wood is done by one and the same machine, which is of a peculiar construction. It consists of two steel blades working together like plate shears. The lower blade is fixed; the upper one moves up and down in a vertical frame. The blades are not straight, but are bent horizontally to a half circle, and their cutting edges are not even, but receding vertically in an elliptic line, so as to start the cut from both sides of the log held between the two blades. The logs, mostly about 12 in. thick, are cut in blocks from 3 to 6 in. high, which blocks are afterwards chopped in smaller pieces by the same machine. As all this is done by regular cutting, no saw-dust is produced. The cutting surfaces of the wood thus treated are not very even nor smooth, which circumstance facilitates the escape of the water in the following operation of drying. The above-described machine works day and night, cutting from 4,000 to 4,800 massive cubic feet of wood in 24 hours. The expenses for cutting by machine and drying of 100 massive cubic feet of wood, amount to about 30 kreutzers. Sawing and chopping by hand of the same quantity would alone cost about 95 kreutzers. In adding to this the expenses for drying, the sum would be too high to be paid for the preparation of wood for the blast-furnace. The wood, after being cut small, is filled directly into the charging wagons, holding about 20 cubic ft. The wagons are pushed into the drying-ovens without being unloaded, and when the wood has been dried, the wagons are conveyed to the top of the furnace. The drying-stove is a brick-building consisting of four parallel compartments. Each compartment is 48 ft. long, 4½ ft. wide, and 5 ft. high, and has a door at each end, the one of which is the charging-door where the wagons filled with wood are pushed into the stove; the other door at the opposite end is the discharging-door, where the wagons are taken out one by one after the wood has been dried. A railroad with an incline of 3 to 100 passes through each compartment, so that the wagons, when pushed through the charging-door, roll of themselves towards the discharging-door. The stove is heated by the waste gases from the blast-furnace. It is, however, provided with a step-grate, on which a small fire is kept burning to re-light the gases when they have been extinguished during the charging of the blast-furnace.

The flame passes from the fire-hearth, near the discharging-doors, into four brick flues running below the floors of the four drying compartments, throughout their whole length; after this the gases pass through the hollow side walls of the com-

partments back to the vicinity of the discharging-door, where they find an outlet into the interior of the compartments, and thus come in direct contact with the wood. They finally pass, together with the steam that evaporates from the wood, through a flue near the charging-door, and escape into the stack.

It is to be seen that with this arrangement the wagons containing the wood pass gradually from the cooler into the hotter parts of the compartments. Each compartment holds 12 wagons, each wagon 20 cubic ft. of wood, the whole stove 48 wagons with a total volume of wood of 960 cubic ft.

At Rhonitz there are only 48 wagons in use, all told, and as a part of them are always on the way to and from the blast-furnaces, not more than 30 wagons are generally in the stove at one time. Both blast-furnaces require about 18 wagons of wood per hour or 60 minutes. Consequently the average time used for drying is about $\frac{30 \times 60}{18} = 100$ minutes, or one hour and 40 minutes.

Most of the wood used has been cut a year beforehand, and is therefore pretty well dried out in the air before being brought into the stove. It loses in the stove about eight per cent of water.

The practical management of a blast-furnace, when run with wood, does not differ essentially from the ordinary charcoal practice. The gas-pipes have to be cleaned oftener and more carefully, because the products of distillation from the wood settle partly in these pipes. The setting-in-blast of a furnace has, of course, always to be done with charcoal. However, after but a few days running, the fuel can be changed, and wood can be used exclusively, provided that the quantity of ore which the wood is able to carry under the existing circumstances has been ascertained by previous experiments. It is, however, very important when wood is used, to make the charges about 60 per cent larger than with charcoal, and to increase the pressure of the blast 10–20 per cent. With too small charges the considerable shrinkage of the wood is liable to produce irregularities in the descent of the ores in the furnaces. The higher pressure of the blast is necessary, because the carbonization of the wood being effected under more favorable circumstances and under a higher pressure in the blast-furnace than in heaps or piles, a considerably better and denser charcoal is produced, which requires a stronger blast to be burnt to full advantage.

The different and better quality of this charcoal has been practically ascertained at Rhonitz by a close examination of charcoal extracted from the lower parts of a blast-furnace running with wood.

It may be concluded, from what has been said above, that dried wood can be used to great advantage in blast-furnaces of at least 1,200 c. ft. interior capacity; when the ores do not pass through the furnace in less than 10 hours; when the wood is cut small, well dried and warm yet when charged; finally, when the top of the blast-furnace is closed, so as to avoid all the disagreements and disadvantages of an open and too hot furnace-mouth.

The use of wood in blast-furnaces has been tried as early as the end of the last century, and the trials have been repeated often in different places. They were, however, without success, from the following reasons. The furnaces were too small and open at the top. The preparation of the wood was done by hand, consequently very expensive, and the wood was not reduced to the proper size. The charges were taken too small, so that irregularities in the smelting ensued.

Explosions have been complained of in some places where the use of wood has been tried. But such have not been experienced at Rhonitz.

The advantages of the use of dried wood in blast-furnaces, in the place of charcoal, may be summed up as follows:

1st. Tops and small branches of trees, the carbonization of which cannot be effected in heaps or piles without a very considerable loss, may be used in the blast-furnace to great advantage.

2d. The whole process of carbonization is done in the blast-furnace in a more advantageous and less expensive manner, so that 18 per cent of charcoal is saved, and all the work that would have had to be expended on its preparation, beginning with the cutting of the trees.

3d. The furnace works well and with great regularity, and preserves a very clean hearth.

4th. Ores or other materials, which melt easily but are difficult to reduce, can be worked more advantageously with wood than with charcoal, as it is shown by the great amount of puddling-slag that has been smelted at Rhonitz, partly mixed with ores,

partly alone. The greater density of the charcoal made in the blast-furnace seems to favor the reduction of these matters.

On the other hand the following disadvantages have to be taken into consideration:

1st. The expenses for cutting and drying of the wood are considerable, though with the machinery used at Rhonitz they are not as high as those for charring.

2d. The cost of transport is greater, because the heavier wood has to be conveyed to the furnaces instead of the lighter charcoal. This disadvantage is but small when the wood can be obtained pretty near the furnaces, and it increases with the greater distance from which the wood has to be fetched.

3d. As above-mentioned, it is necessary to clean the gas-pipes oftener. This disadvantage can, however, be entirely removed by erecting an apparatus for cleaning the gases from all the easily condensing substances. By this operation tar would be obtained, the value of which would pay for the expenses.

In general it may be said, and it has been proved by long practice at Rhonitz, that the disadvantages connected with the use of wood in blast-furnaces are by far out-weighed by the great savings effected by it when properly managed, and it is to be expected that the use of wood will enable many charcoal furnaces to withstand the increasing competition of the coke and anthracite furnaces. S.

RAILWAY DISASTERS.

WHAT KINDS OF DISASTERS CAN BE EASILY PREVENTED BY LEGISLATION.

From the "New York Times."

The awful frequency of railway disasters has at last set people to thinking whether some practicable means cannot be devised to prevent or lessen the horrors that attend them; and many theories of railway safety have been set forth in the newspapers by unprofessional experts, to the utter bewilderment of the public. But we have yet to learn that a single step has been taken by railway managers or by the Government to abate certain unquestioned and notorious causes of disaster which we shall enumerate —causes as well defined at Angola, Carr's Rock and Pine Tree, as at Mast Hope.

The misplacement of switches, for instance, even by men considered careful, often occurs, but the English system of signals would warn both engineman and fireman of the fact in *ample time to stop*. Hundreds of lives might have been saved by thus widening the range of notice and responsibility—it is almost impossible that three men will blunder in such a matter at the same instant—and yet not one in five hundred switches, passed by express trains at the top of their speed, is so guarded. We have, on a previous occasion, shown that not less than five men, practically asleep at Mast Hope that fearful night, might have saved the train if the appointments and regulations of the road had been adequate.

The preservation of trains from wreck, by safety brakes instantly applied to all the wheels, must have been a matter of experience with many of our readers; it has been so not less than three times with the writer, on one of the roads leading out of this city. But the use of such brakes is hardly increasing, and is not general.

An American train being connected merely by slack couplings, each car is free to sway laterally and vertically, even to the extent of jumping off the line, without restraint from the adjoining cars. The late Pine Tree disaster was, in the opinion of experts, especially of English engineers, who have commented severely upon it, greatly aggravated by this cause, and it is certain that many slight mishaps have grown into awful catastrophes for the want of the simple English appliances by which a train becomes an articulated whole, instead of a series of disjointed and independent pieces, each surging about without any restraint. On one of the few American lines where this system has been partially applied, it has been substantially neutralized by *adding the old links*, which are, of course, always used to save trouble.

Experts generally are of the opinion that a narrow-gauge car cannot run with the highest safety through wide-gauge frogs and guard-rails—in fact, that the late fearful Angola slaughter is a case in point—yet the inch and a half difference of gauge remains, and the number of cars suited to the one, and consequently unsuited to the other, but run over both, is constantly increasing.

The breaking of rails does not often occur when reasonable care is taken as to their quality and laying. Yet it is the opinion of the many engineers whom we have consulted, that a reasonable measure of safety cannot be secured without continuous longitu-

dinal sleepers, or some mechanical equivalent thereof, which shall hold the broken pieces of rail in place long enough to pass a train in safety. But there is nothing of the kind in use.

Again, if there is anything clearly and positively settled in railway practice, it is that ricketty "permanent way"—broken chairs, rotten sleepers, loose spikes and rails, with parts of the head split off—are utterly and frightfully unsafe. But we will undertake to show any competent Government committee just this kind of track *by the hundred miles*—track that any commission of experts would refuse, upon examination, to ride over at high speed, and which is habitually left in this condition month after month. Yet when trains run off tracks of this general character, juries are utterly at a loss to account for it, and fall to speculating on the occult molecular differences in irons, the moral character of employees, and everything but what is obvious and pertinent.

There are in New England hundreds of old wooden bridges, designed when the stress put upon materials was much nearer the limit of strength than is now deemed safe—bridges that have deteriorated in the alternate rain and shine of twenty years, and which, being built for fifteen or twenty ton engines, are to-day straining under those that weigh 25 and 30 tons—bridges in which, according to engineers and bridge-builders, whom we have consulted, the iron rods are strained, when two engines happen to meet, up to 50,000 lbs. per in., when 10,000 lbs. is considered a safe working load. Now and then a wooden bridge falls under a train, and it is a dreadful but inevitable conclusion that hundreds of lives are yet to be sacrificed in this manner.

The most unnecessary, and at the same time the most frightful risk of railway traveling is yet to be mentioned—it is the risk of mangling and roasting by the splinters of the wooden car, that comprehensive and labor-saving engine of torture, for which, had the Adversary hatched it in their day, the Spanish Inquisitors would have thrown aside all their limited and clumsy contrivances. Upon violently striking any rigid object, the wooden passenger car is as certain to go off as a bombshell, with this advantage over the bombshell, that it has a percussion fuse at every angle, and completely surrounds the objects it is to destroy. Seriously, the wooden car is *certain to break up* in case of collision or derailment at high speed, and then the burning of the passengers is probable—their mangling is inevitable. Every few months, men, women, and little tender children are tortured to death, and this awful fate is certainly reserved for some of us. But not a single step has been taken by railway managers to abate this evil, though the remedy is practicable, and even economical in the long run. Iron cars neither splinter nor burn, and will out-wear wood again and again—yet we do not know that a single iron passenger car is contemplated.

We have thus specified a few of the most notorious and unquestioned causes of railway disaster—causes which do not involve the so-called hidden and unsearchable nature and changes of materials, nor any mere theories of construction, nor the vigilance and responsibility of employees. The remedies for all these universal, unfailing and ever-menacing evils are precedented and practical; some of them are almost ridiculously inexpensive; some of them would save their cost every year in lessened wear and tear, and all of them are feasible, simple and unembarrassed subjects for legislation. How many more murders will our law-makers ignore?

STEAM BOILER INSURANCE IN AMERICA —THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.—However unfortunate we in England may be in the matter of steam boiler explosions, no one can fail to have observed that our friends in the United States are still more so. The annual loss of life and property there, from this cause, must appear very large, even to the casual observer, whilst to those whose attention is frequently drawn to the subject, the results are really startling. It will be sufficient for the present purpose to allude to the record for the past two years, as it found its way into the papers. Such a record is, of course, a very incomplete summary of the number of lives lost, and the amount of property destroyed by boiler explosions in the time specified. Many explosions of a more or less serious nature are never reported by any newspaper, or, if reported, fail to meet the eyes of those interested in preserving an account of them. Incomplete, however, as it is, when we note the fact that, during two years, upwards of 800 lives have been lost in America by

boiler explosions, and an immense amount of valuable property destroyed, ranging—in the various instances where any estimate was given—from $500 to $50,000, it demonstrates very conclusively the need of such a system of boiler insurance and inspection in that country as we have in our own. This necessity has been recognized—somewhat tardily, perhaps—by the Americans, who took a leaf out of our book, and in 1866 started "The Hartford (Conn.) Steam Boiler Inspection and Insurance Co.," about which association we have to say a few words. We are induced to do this from the fact that our journal finds favor in many parts of the States, where our persistent advocacy of boiler inspection is well known, and where the advantages of the system are admitted. If, then, the correctness of the principle be allowed, and if we point out to those who may not be aware of it, that American steam users have the same opportunities of making themselves safe as we in England have, there remains no excuse if they do not avail themselves of the means offered.

The Hartford Association is the pioneer company of the United States, and from particulars recently forwarded by a correspondent, we find that during the two years and a half it has been in operation, it has extended its business by a system of well appointed agencies over a great part of the country. Many of the largest manufacturers hold its policies, and its rapidly increasing business attests the value of its work. Its business is confined to no particular form of boiler, nor to any special class of manufacturers. It embraces ironworks, mines, cotton and woolen mills, saw mills, locomotives, steam-boats and steam-tugs, and, in short, all establishments where steam-power is used. All boilers under its care are carefully inspected, internally and externally, by competent practical men four times a year. Steam gauges are tested, safety valves properly adjusted and weighted, boiler connections carefully examined, and information given relative to setting and management. The end and aim of all this, be it remembered, is economy in the use of fuel, and safety to life and property. As a matter of course, the work of the company has brought to light many and dangerous defects; and there can be little or no doubt that disastrous explosions have been prevented. We know that where boilers are left unexamined for months and years together, incrustation, internal and external corrosion, burned plates and blisters, shorten their working age, and render them positively dangerous. The usual mode of inspection, applying the hydraulic test, takes no cognizance of these defects, and does but little towards insuring safety. The policy of insurance which the company issues, covers damage to boilers, buildings, stock and machinery, arising from explosions, and is a guarantee that the inspection has been thoroughly effected. It stands to reason that self-interest would cause the work to be properly done, inasmuch as the party making it has a pecuniary interest in its issue.

The company imposes no arbitrary conditions; it is interested in no patented appliances, but on receipt of the proposal for insurance, together with the inspector's report, the boilers are classified and accepted at a proper rate per cent, unless they are found on inspection absolutely unsafe, in which case the applicant is furnished with a written statement of their condition. Information relative to the management of steam boilers, monthly reports of the inspectors of the company, a list of explosions, so far as they can be obtained, for each month, and other valuable information, is disseminated amongst the policy-holders by means of a monthly paper called "The Locomotive." From what we have advanced, it will be seen that the Hartford Association is conducted upon equitable principles. The present remarks are penned with the view of promoting the interests of those steam users who are indifferent to themselves, and of increasing public safety. We, therefore, trust that they may lead those who may read them, and who have hitherto held back, either from ignorance or obstinacy, to avail themselves of the manifest advantages of inspection and insurance. It is an old and oft-reiterated opinion of ours, that it is due to the State that every man should adopt every precaution in his power to protect the life and property of his fellow subjects. A persistent disregard of this principle is a flagrant violation of the moral law, which the State will not always permit with impunity to the offender. —*Mechanics' Magazine.*

THE CORLISS ENGINES at Woolwich Arsenal, are using from 3.3 lbs. to 3.7 lbs. of coal, per hour per horse power, as shown by the daily engine reports.

BETON BUILDING.

From "The Canadian Builder."

Of all the compositions which in late days have been introduced as substitutes for brick and stone-work, there is not one that presents more attractions as a material than beton. But the use of it is limited to those localities where water lime can be had at a reasonable price. For, although that admirable cement is about the only one of its component parts that is expensive, yet the proportion used makes the beton more costly than could be wished, notwithstanding its many merits as a building material. There need not be any stone or stone chips used in the making of beton. All that is required to make a quick setting and very durable material is, sand, three part; water lime, one part; broken brick, six parts. The water-lime and sand should be well mixed together, dry. Then have as much water thrown over as will make a moderately stiff mass, when it is to be instantly transferred to the moulds, which are already in their place on the walls, and the center to be packed with the broken brick, which being very porous, will receive the moist cement readily on its broken faces, and help to set the whole. The mode of constructing the courses is by means of moulds easily adjusted and taken apart. They are to be calculated so as to enclose a block of beton of the required thickness of the wall, and half again that thickness in length. There height may be ten inches. Thus, if the wall be twelve inches thick, the block will be the same, and also eighteen in. long by ten in. high.

We will proceed to describe the operation of building as carried out in the construction of a beton house at Black Rock, near Buffalo, some years ago. The lines being laid out, the basement was excavated to the depth of six feet, and the trenches for the foundation walls dug out one foot and a half below the bottom of the basement. These trenches were two ft. and a half wide, that is, three in. each side wider than the basement wall above them. The basement was therefore dug three in. wider than the plan all around, and this was done to leave room for the placing of the moulding boxes with their rods. The bottom of the trenches was made level, and these were filled with concrete composed of six parts gravel, four parts sand, one and a half parts quicklime, with sufficient water. When this mass was well mixed and turned over three or four times, it was thrown into the trenches in layers or courses of four in. in depth. Each course was spread over the whole of the foundation trenches, until they were all, including the foundation of cross-walls, filled. When the surface of the basement or cellar bottom was reached, then the whole area was gone over with a coat of gravel, and over this was poured a creamy mixture of water lime and sharp river sand, in equal proportion, until the whole was flash. This was done on Saturday, and on the following Monday the floor was hard enough to walk upon. The basement walls were now commenced in the manner here described. The lines of the walls as shown on the plan were carefully laid out, and angle-moulds placed at each corner, with straight moulds set at equal distances all along.

One corner mould and three or four straight moulds are sufficient to work with; but the greater the number of moulds the more expeditiously the operation of building goes on. When all was ready, the corner moulds were filled first, and then the other moulds regularly in turn. When all were filled, the moulds were taken apart and set up at other points along the walls; but sufficient time was given for the beton to become hard enough to admit of being uncovered. The walls being thus gone round the next operation was to enclose the spaces between the beton blocks, and this was done by using the sides of the moulds, without the ends, and holding them in place by the following means: Two pair of pieces of scantling two by three in. each, and two ft. long, were set upright at the ends of the side boards, and bearing them against the beton blocks. At the middle of their length they were held by the rods and screws used in the moulds, and their upper ends being apart by sticks of the necessary length, the boards were thus clutched and kept in place. These inclosed places were now up flush in the same manner as the moulds, and by packing and tamping, the connections were rendered so complete as to make the whole a uniform mass. When each course was in this manner completed, the moulds were laid for a new one, taking care to break joint though no joint was visible, yet this precaution was taken to avoid any continuous joint or point of imperfect connection. Where doors or windows occurred, the moulds were placed correspondingly, one on each side of such opening; for it may be observed that there is no necessity for the

fixing in of the frames until the work is all sufficiently set. However, it is necessary to insert these moulds at doors and windows, at the ends, which will form the jambs of such pieces of scantling called stops, four in. thick, and sufficiently wide to permit the future, frame to rest five or six in. back from the outer face of the wall. Of course the frame can be set up and the jambs worked up to it, but it is more troublesome and will scarcely make as good a job. The window-sills and caps were provided for in like manner, and there was a splay left in the window jambs. by means of angular pieces being added to the above mentioned stops, which gave the required mould to the beton. When the level of the ceiling was attained, the flooring joists were all set up in their places, and temporary bridging of plank fixed between every every pair, so as to hold the beton which was thus continued up, making a compact bed for the joists, and effectually preventing the lodgement of vermin. The short boards or pieces here used may be removed when the work is set, as they will be wanted again on the next floor. In the building we describe they were left in, but it is not at all necessary.

The joists being all flushed up with the beton, the floor boards were nailed down and the beton again flushed up to the surface of the floor. The moulds were now placed for the walls of the principal story, which being six in. less than than those of the basement, the ends of the moulds were made in accordance with the new thickness, namely, twelve in., and the work went on as before, with the exception of the corners of the main walls which were rounded by means of blocks of the necessary shape being set in the angle. This rounding off of the wall on the outer corners gives a very neat appearance without adding to the cost. On the contrary, it economizes the material; for the thickness of these corners instead of being greater on the diagonal, is exactly the same as that of the straight walls throughout. In the manipulation of the beton for the walls of the superstructure, it was deemed advisable to pack the front of each mould with a finer coat of cement than that used at the heart, or even at the back, so as to give a uniform face to the outside. This face was carefully troweled into the bed made for it in the mould, by working back the coarser beton in which the broken brick was packed. In the top of the first tier of blocks forming the course, an angle mould was laid along and pressed into the fine beton forming the outside face. And on the bottom of the next tier of moulds, a corresponding angle mould was laid and the beton cast firmly around it. And thus every course was treated. The consequence was that the cincture left on the removal of these moulds produced an effect on the exterior remarkably like coursed masonry, the course lines being of the $>$ shape, about two in. wide, and one and a half deep. Other sections of cincture can be moulded to suit other designs of building. After each course was uncovered, these sunken mouldings were finished smooth by working a whole mould of the $>$ shape along them, backward and forward. Perpendicular moulds of like shape might have been made to mark out each block, and no doubt would have improved the appearance of the building. The sunken horizontal courses were carried all around the house and produced a good effect. The next floor was flushed up at the joists precisely in the same manner as the first or principal floor. The windows and doors all set in and worked up to. But this is not the better way. The sills and lintels were of oak, but the latter did not show on the outside. It would be much better to have stone sills and lintels. The partition walls were six in. thick, and were cast in unbroken courses, with the exception of openings for doors. The door cases were set in and worked up to. Blocks were nailed to the floors at the walls and partitions, to receive the base board of the apartments—and these blocks were covered up in the beton. In like manner there were blocks inserted for nailing finishing of windows and doors to, and for holding the horizontal slates from which to hang pictures. The roof was a gabled one, of a fourth pitch, but a Nansard would have been a great improvement. The walls were skin coated on the inside of the house, and the best rooms were hard-finished. Nothing can be easier for the plasterer to make a workmanlike job with; for his material is sure to adhere to it. There is little more to add, save that the chimney-flues were all cast round by means of stovepipes used as moulds and left in. This is not a good plan, as the stovepipe will corrode after a time, and it is very difficult if not impossible to remove it. It would be better to use a movable cylinder mould with a handle, and have the flue finished smooth in beton. The chimney shafts can be very ornamentally finished with terracotta caps,

To those who can procure water-lime at anything like a reasonable price, we would strongly recommend beton as a particularly applicable material. It is warm in winter, cool in summer, and at all times dry and healthful. In mixing common lime with it —of course for economy's sake alone—it will be well to bear in mind that, whilst quick lime swells in slaking about one-fourth, water-lime on the contrary shrinks about a fifth. By experiment on the limes to be used, exactness can be attained. By thus calculating, the two may be, so to speak, dove-tailed into each other.

INDUSTRIAL PARTNERSHIP.

A humane tendency towards the improvement of the condition of the working-classes evidently exists in all civilized countries. Many systems have been invented and tried, and many have failed. The old French communistic principles have been found totally impracticable. No means have succeeded in England as yet to universally prevent great and long-continued strikes so ruinous to both capitalists and workmen. The idea of Lassalle in Germany that the "help" has to come from the governments, was not able to rouse the latter from their impassibility, nor to inspire confidence in the greater number of the workmen. The second empire in France undertook to calm the laboring classes by an unprofitable occupation, at the expense of the whole people, in the embellishment of the capital. This great and beautiful but to a great extent fruitless work is not yet fully accomplished, and already we hear of seditious scenes that occur in the embellished capital. In this country the vain attempt has recently been made to regulate by law certain relations between capital and labor, relations which under a despotic goverment only, could be regulated otherwise than by the free will of both the concerned parties, by voluntary agreement between free men and free men, between laborers and capitalists, when they acknowledge each others rights and when they recognize and own that the interest of the one is the interest of the other. The eight hour law was totally ineffective, as might have been expected before hand. A real and great success in improving the condition of the working-classes was, however, obtained in Germany by Schultze-Delitzsch, whom A. S. Hewitt in his report of the Paris Exposition of 1867, calls therefor "the greatest benefactor of the human race in our days." This system is based on the principle of "self-help" through associations of consumption, of work, of money, through education and enlightenment, inevitably followed by moderation and good sense. In other places may be read the accounts and statistics of the great number of societies for supply of materials, for co-operation for mutual credit, for acquiring a higher than the ordinary school-education, as they have been established among workmen all over Germany, especially under the influence and practical guidance of Schultze-Delitzsch. Great as this success may be, yet the question is considered in Europe where its solution is more urgent than here, of such a high and immediate importance, that new schemes yet continue to turn up and to be discussed. There is one amongst these which merits special attention because it benefits both capitalists and workmen, and because, to judge from the practical successes already obtained, it seems to be the proper way to perfectly unite in single instances the interests of both. It has been called "Industrial Partnership," and consists in giving to the workmen an actual interest in the business for which they work.

In a meeting of the engineers of the Lenne-district, held at Lethmate (Prussia) on the 12th of July, 1868, Mr. C. Kugel delivered a lecture on this subject from which we extract the following interesting remarks.

"In England where this system has originated, the motives which led to the first trial, were dictated to the capitalists not by humaneness, but by mere egotism. The relations existing between employers and employees in many districts were then such that the two parties stood opposite each other like two hostile armies, ready at any time to begin an open war. To alter this condition injurious to both parties, it was thought of granting the workmen a share of the profits, thus to inspire them with more interest for their work, thereby to increase and improve the production and to attain to the greatest economy in the manufacture. It was expected that carelessness in working would thus be checked or at least greatly diminished, because the workmen would mutually control themselves.

"The first trial with Industrial Partnership was made at the large carpet factories of Messrs. John and Francis Crossley at Halifax (Yorkshire). These works embrace an area of 18¾ acres of land and a capital of £1,500,000. They employ 4,500 persons.

Messrs. Crossley divided the whole of their business-capital into shares, the fifth part of which they offered and sold to their employees at £15 per share. By this operation they obtained not only perfectly satisfactory relations with the workmen, but a great material gain. Within the first three years after the introduction of this system, the yearly dividends amounted to 15 per cent, and a reserve capital of £11,284 was aemulated besides. In the greatest financial crisis the value of the shares of this company did not sink below £17. A success more brilliant yet was obtained through Industrial Partnership at the coal mines of Messrs. Briggs at Whitewood and Methley junction, near Normantown. Continual dissensions between the proprietors and the men existed at these mines from 1853 up to 1863. In the years 1858 and 1863, regular strikes took place. The proprietors in consequence concluded to sell one-third of their mining-property to their workmen, and to other persons in shares of £15, of which £10 had to be paid in at once. The workmen at first showed some diffidence. But very soon the demand for shares increased to such an extent from all sides that Messrs. Briggs kept in their own hand only 6,450 of the existing 10,000 shares. They sold 1,-068 to their customers, 1,847 to the general public, 114 to their agents and 264 to their workmen; 230 more were reserved for further purchases from the latter. The office-employees took 86 shares, and the other 178 were sold to 83 miners and 61 laborers. As the works occupy in all 785 miners and 204 labores, one share is, in the average, in the hand of one amongst nine miners, and one share is in the hand of one amongst three laborers. No one, Messrs. Briggs of course excepted, can hold more than 6 shares according to the agreement. These mines which in former years in consequence of strikes and bad work, did not pay any interest whatever, have been able to distribute from £15,000 to £18,000 of dividends in the last three years and have besides accumulated a considerable reserve.

"The North-western Manufacturing Company in Chicago introduced the Industrial Partnership in the following manner. The weekly earnings of every workman were calculated from the average wages for a daily work of 10 hours. It was agreed that the whole body of workmen should receive in addition to their regular wages, the one half of the net profits exceeding 10 per cent of the capital. The distribution of these profits is effected in proportion of the wages earned by every single man, as found by the just mentioned calculation. The shareholders are to receive 10 per cent of the capital and the other half of the excess. According to communications received from Chicago, $50,000 of profits were obtained from one year's business with a capital of $250,000. The share of profits paid to the 140 workmen of the factory were therefore $12,500. Mr. Borchert, jun. in Berlin (Prussia) was the first German house who made a trial with the system of Industrial Partnership. Mr. Borchert estimated the value of his establishment at 300,000 thalers and divided this sum in 12,000 shares of 25 thalers each. He allows one-tenth of them, or 1,200 shares, to be bought and owned by his workmen and employees. The share-holders constitute a company for themselves. They elect three of their members as directors. The latter have the right to inspect the books, and they receive every month full information on the condition of the business from the proprietor who is also the general manager of the factory. As soon as three-tenths of the shares will be sold, the directors elected by the shareholders, will have a direct influence on the business transactions. One half of the net profits (probably after deducting a certain interest on the capital) is divided among the workmen in proportion to the wages received. These, however, who are steadily employed and paid by the week receive a greater part in proportion than those who are paid by the piece. The other half of the net profits is divided amongst the shareholders."

After having made these communications, Mr. Kugel in his lecture further alluded to the difficulties which in many places may oppose themselves to the introduction of Industrial Partnership. He thought however that, to judge from the brilliant success obtained with it in some establishments, it deserves to be warmly recommended. The introduction has of course to be done cautiously and with special regard to local circumstances. He finally expressed the opinion that the institution of Industrial Partnership will prove a better and safer step toward the solution of the so-called "social question," or the question of the improvement of the social position of the working-classes, than even the institution of productive associations.

We cannot conclude this article without directing the attention of our readers to a remarkable feature which some of the above mentioned examples of partnership have in common. The proprietors do not sell a certain number of shares to their workmen without selling at once a much larger number to outsiders. This appears to be an important point which prevents direct disputes between the shareholding workmen and the proprietors about the profits and the dividends. This remark does not of course, apply to those cases in which the proprietors, without selling any shares, distribute amongst their workmen a certain part of their profits as a free donation. S.

MAKING FOUNDATIONS IN MARSHES.—A new process of making foundations for bridges in marshy soils has been recently used on a branch line of the Charentes Railways Company in France. This line crosses a peat valley to the junction of two small rivers; the thickness of peat was so great that any attempt to reach the solid ground would have been very expensive. In order to obtain cheaply a good support for the bridge, two large masses of ballast accurately rammed were made on each bank of the river, and a third one on the peninsula between the two. The slopes of these heaps were pitched with dry stones, for preventing the sand from being washed away by the rain or by the floods in the rivers. Over the ballast a timber platform is laid; this platform carries the girders of the bridge, which has two spans of about 60 ft. each. When some sinking down takes place, the girders are easily kept to the proper level by packing the ballast under the timber platform; this packing is made by the platelayers with their ordinary tools. This simple and cheap process has succeeded quite well.

The same difficulty was overcome by a different plan on an ordinary road near Algiers. This road crosses a peaty plain nearly one mile broad; the floods and elasticity of the ground prevented the formation of an embankment. The road was to be carried over a viaduct across the valley, but the foundations of this viaduct presented serious difficulties, the thickness of peat or of compressible ground being nearly 80 ft. It was quite possible to reach the solid ground with cast iron tubes sunk with compressed air, or with any other system, but neither the implements nor the suitable workmen were available in the colony, and it was a great expense to bring them, and especially the workmen, from France. The use of timber piling was of course out of question, as timber is very expensive in Algiers and quickly becomes rotten; but there was a set of boring implements with the men used to work it. The engineers began boring holes 10 in. diameter down to the solid ground. These holes lined with thin plate iron pipes were afterwards filled with concrete up to the level of the ground. Each of these concrete columns bear a cast iron column; these columns are properly braced together and support the girders of the viaduct which is divided into spans of about 20 ft. and is 20 ft. high over the ground. This system has succeeded very well, and is to be extended to another larger valley.—*Cor. The Engineer.*

STEAM AND POWER HAMMERS.

From a paper before the Civil and Mechanical Engineers' Society, by Mr. FREDERICK H. ROBERTS, C. E.

The author referred in detail to some of the earlier machines, such as the helve or tilt hammers used for shingling, forging blooms and shafting, tilting steel, etc., but as this class of machine depended, to a great extent, for raising the hammer and its connections, either through the direct medium of cams, eccentric, or similar arrangements, it followed that the power required to work them was extremely large, and the parts of the machine itself very heavy and cumbersome to withstand the consequent strains. It was also found that the larger the mass of metal to be worked, the lighter the blow given, and, conversely, the smaller the mass, the heavier the blow; it was, therefore, ill adapted for heavy forgings. The invention of the steam hammer solved the difficulty which was found to exist, and to it, to a considerable extent, is due the perfection obtained in all classes of machines where ponderous forgings are found to be absolutely necessary.

The first idea with reference to the steam hammer the author traced as belonging to that great engineer, James Watt, who obtained a patent, in 1784, for heavy hammers or stampers, for forging iron, copper, or other metals without the intervention of rotative motion, by fixing the hammer head either directly to the piston or piston-rod of the engine. Another patent followed this in 1806, by a Mr. Deverell. He proposed

to admit steam underneath the piston of an engine by means of a valve, and during its up-stroke the air at the top of the piston was compressed by the pressure of steam beneath, which was released at the proper moment. The compressed air on the top of the piston, in addition to the gravity of the hammer head, was to give the blow. But neither of these ideas were put into practice at that period, and it was not until 1837 that any practical design was put forward for a steam hammer, and then by Mr. Nasmyth, of Patricroft, who urged its superiority for working metal over all other machines, but was unable to procure its adoption until about 1840, when he found that M. Schneider, of Creusot, profiting by his design, had constructed a machine on his plan. In 1842, he obtained a patent for his steam hammer, and from that time it became a recognized power, and a necessity in all works of importance. The facility which it afforded for executing all kinds of forging had the effect of greatly increasing the quantity of work to be done, and effecting a material saving both in time and labor.

The steam hammer, as originally constructed, required the valves being worked by hand, which left the machine in the power of the workman to give proper efficiency. The valves were also very difficult to work. This plan answered for the time for small machines, but where rapid motion was necessary, and for larger hammers, it was unsuitable. Several designs for self-acting motion, therefore, followed in quick succession. The author then referred to the different designs that had been introduced for this purpose. In the ordinary self-acting hammer, the man has to watch the metal under operation, and, as its form and position change, he must set his valve gear to suit as near as possible. The author considered that the motion, to be properly self-acting, should be independent of the workman as regards the adjusting of the gear to suit the varied thicknesses of the metal on the anvil; and, in order to obtain the full force of the blow, it should reverse simultaneously with, or immediately after the blow is given, and at whatever point in the stroke the blow takes place. He considered that was accomplished in Sturgeon's double-action hammer, where the blow itself was made use of as the agent to work the valve, and described the mechanism employed; also the various types of double-action steam hammer; likewise the numerous modifications and improvements effected. The author then spoke as to the specialities of the heaviest classes of steam hammers of modern date, including those of Mr. Ramsbottom's design; likewise those erected for M. Krupp, at Essen.

With reference to machines of a lighter class, the author described the various designs for power hammers, and referred to the patent pneumatic hammer, several of which he had erected, and which are specially adapted for general smithy work, or light forgings, planishing and beating out metal, etc. It is extremely simple in action, working by means of the alternate exhaustion and compression of air within two cylinders, in one of which is a piston, to which the hammer head is connected by means of the piston-rod. By opening a small valve, the vacuum formed within the cylinder is destroyed, and the blow weakened or stopped instantly, according to the amount of the valve opened. The machines are capable of working up to 500 blows per minute when required.

IRON-FOUNDING.

UNITING CAST-IRON BY "BURNING-ON."*

From the "Practical Mechanic's Journal."

Connecting lead with lead, by running a stream of very hot liquid lead, suitably confined, in contact with a surface of solid and cold lead, until the latter had got to its melting point, and then stopping the current, so that the two portions become united when both solid, has been known to plumbers for ages under the name of "burning together." In fact, by this method some of the earliest lead water pipes were made before "drawn pipe" was known.

This same method of "burning together" may be also employed by the iron-founder, and occasionally with great advantage. The writer, in the course of his early practice, had occasion to cast four of the very ponderous columnar cast-iron frames which, in the earlier days of steam navigation, were to be employed for the "side frames" of side-lever marine engines of the heaviest class. The frames in question consisted of coupled Roman-Doric columns of considerable diameter, cored out, with cross framing and entablatures, also all cored out, and with sundry projecting pieces like truncated horns etc., whereby the frames were to be united

* See also Van Nostrand's Mag., No. 8, page 705.

with other "thwartship" pieces, each frame weighing several tons and consuming a large amount of wages in moulding.

All four were cast sound and without a blemish, except that, upon the top box in which one of these was cast—all being cast in green sand—some one had unluckily dropped a bar or something heavy, or put a foot upon it, and produced "a crush," which rendered one of these horns utterly amorphous. The casting, otherwise perfect, was in that state absolutely useless, and was about to be broken up, when the writer resolved to try and save it by attempting to "burn-on" a new and perfect horn. The old and defective mass was carefully cut off, and removed down to absolutely sound metal. "Loam cakes," having the proper form for the horn, were taken from the pattern, the surface of the cut metal was well dusted over with powdered glass of borax, after that the mass of the "frame," in close propinquity with the defective place, had been heated red-hot in a coke fire built up around it. The fire was then raked away, the loam cakes secured in place, and several hundred weights of very hot liquid cast-iron were for some time kept flowing through the cavity of the loam cake hollow-mould. At length the flow was stopped, when the cut surface could be felt, with the point of an iron bar pushed through the running metal, to have become pasty and soft, and the iron was then permitted to set. When finally stripped and "gaits" etc. removed, the new horn was found to be perfectly united with the remainder of the casting, and when struck it gave the clear sonorous ring which proves complete metallic continuity.

The success, in fact, was perfect, and somewhat surprised both the writer, to whom so large an instance was new, and the marine engineer responsible for the supervision of the work, who would not pass the casting until he had assured himself of the safety of the horn by striking it heavily with a sledge-hammer. This method is capable of being applied not unfrequently with similar ends in view, and may often save the condemnation of a casting and effect a good deal of economy. It can almost always be made effective, if the methods be judicious, for attaching, as in the above case, a heavy piece to a heavy casting; but it is a far more delicate and difficult task to make succeed with smaller and more delicate work, and there are two generic cases in which it is useless to attempt it.

One of these is where the form or dimensions, or both, of the casting must remain *precisely* the same after the work as before; as, for example, if a piece be defective in the rim or in one of the arms of a large spur or head gear-wheel, there would be no great difficulty in replacing it soundly by casting together as described; but either the wheel would crack somewhere on the setting of the "burnt-in" metal, or during its cooling, or it would have lost its circular form and "truth" when all should be cold.

Again, if the mass of casting be very great, and it is but a whole or cavity, regular or not, that requires to be filled in with metal, which must be perfectly united with the remainder, this can scarcely be accomplished unless at an expense that renders the process worthless; for *the whole* huge mass must be brought to a strong red heat, with great expenditure of fuel and time and surface injury to it by oxidation, or the union will prove imperfect. Such has been the fate which has always attended attempts, thus to restore defectively cast cylinders for hydraulic presses. The writer, however, has little doubt but that a sort of small coke-fed furnace, with a strong blast, delivering from a small brick-lined mouth a jet of flame like that of a large blowpipe, might be so used as to heat even up to the melting point—and but very locally or partially—any mass of cast-iron, however huge, so as to admit of "burning on" to it. He once witnessed sufficient proof of this in the method taken to repair a defect which appeared in the neck of a very heavy cranked intermediate shaft for marine engines, at the Thames Iron Works, just before Mr. Mare ceased to direct them. The neck of the crank, about eighteen in. diam., was rough-turned, when a hole was found and cut into in the forging, close to the angle of the neck where joining with the arm or side of the cranked part. Nothing could be more awkward as to position, and the condemnation of the whole forging, and serious loss, seemed imminent. The foreman blacksmith determined upon one trial to save it. He got up just such a coke-fed giant blowpipe as has been described, and drove its flame right into the defect or cavity, having carefully "clayed up" the iron of the rest of the crank adjacent, to save it from oxidation.

In about five hours he had the interior of the cavity at a fine uniform and clear welding heat. A piece of wrought-iron, well-

judged—as to form—to rather more than fill it, had been got ready, and at the right moment was brought, in a forge-fire, to a welding heat also; and the blowpipe blast being thrown off, the welding hot plug, preceded by a dust of sand and borax glass, was thrust against the cavity, and a single blow of a "tup," beforehand properly swung ready, sufficed to firmly weld it into place. The superfluity, when cold, was chipped off, and the turning of the neck completed, which the writer witnessed; and he can testify that it was not possible upon the clean cut surface then to discern where was the new iron, and where the surrounding old of the original forging. The work reflected much credit upon the skill of those who conducted it, and in that respect alone deserves to be recorded. The method of heating, however, is quite as applicable to cast as to wrought-iron.

The marine-engine framing above referred to was treated about 1833. In the "Annales des Mines" for 1860, M. Mengy gives a circumstantial account of the same method having been applied about the same date at the Tamaris Iron Works, Departement of Alais, to burning-on the broken-off necks of the iron rolls of the rolling mill, and with complete success. Dr. Percy ("Metallurgy," p. 745) states that he has seen a roll thus repaired at the Millwall Iron Works, and that the method has been in occasional use elsewhere.

Dr. Percy also gives an interesting account of the Chinese method of mending or stopping holes in their very thin cast-iron rice bowls or boilers, when broken through these brittle vessels, by means of a plug of pasty cast-iron adroitly applied by the native "tinker." He cleanses the edges of the hole, melts a sufficient large bit of cast-iron in a small crucible, in a little charcoal furnace, tilts the liquid iron out upon a folded damp cloth spread with ashes and held hollow in the hand, and at the moment before the cast-iron assumes the *pasty state* just before "setting," he thrusts it up to the outside of the hole and through it, and smoothes the overplus at the inside with another like cloth; so that he has thus made a sort of irregular rivet of the semi-liquid material. There is here, however, no metallic union. The case is precisely analogous to the manipulation by which the plumber makes a "wiped joint," applying the semi-liquid plumbers' solder, held in the hollow of his "tickenfelt," rapidly and adroitly to and around, the shaved and tallowed surface of the adjacent ends of the lead pipe to be united; and equally analogous to the way that holes in earthenware vessels are sometimes mended in this country, by a semi-liquid rivet of fusible metal quickly pushed through and smoothed over on both sides. It is not impossible but that more extended uses of this same method and of the analogous properties of cast-iron, though at its much higher temperature, might be found if looked after.

Where a mere cavernous defect exists in castings which injures appearance only, and which may be filled up level as sufficient remedy, cast-iron is very often dropped into the hole and the surface instantly scraped or cut off level by shoving an iron straight-edged scraper across the mouth of the now filled-up hole. This, however, is seldom a very neat method of repair, and some iron-founders adopt for the filling material an alloy which is almost identical in color with the dark surface of freshly-made castings, but is much more fusible than cast-iron.

This alloy is said to be best composed as follows:

	Antimony	65
	Copper	16
	Lead	13 by weight.
Some prefer—		
	Antimony	69
	Copper	16
	Tin	2
	Lead	13 by weight.

The copper, tin and antimony are melted together first, and the lead then added.

Where, for such operations as are above referred to, defective or other parts of castings, more particularly of large size, require to be cut off, if there be suitable appliances at hand, they are much more easily removed at a cherry-red heat by means of a rapidly rotating circular saw, as in cutting off the ends of rolled iron rails, than by cutting away with machine tools or by hand, cold. Indeed, in many ways besides this, cast-iron is an extremely tractable material at a low or cherry-red heat. Thus, for example, at that temperature, castings which have been molded flat may, if need be, be curved by bending over a saddle of suitable form and to almost any extent.

Or curved pieces, buckled in the cooling, may be forced back flat, or the curvature of pieces, which have too much departed from that of the model, by contraction in cooling, may have their curvature corrected, etc.

The writer once cast a great number of very thin perforated flooring plates for a bridge, which were required to be curved into arch plates. They were cast quite flat, which, owing to peculiarities of form and perforation, was found the best plan to secure soundness, and then curved by bending over a saddle of baked fire-clay; for the saddle must not be of good conducting material, or the casting gets chilled and possibly broken.

BLACKFRIARS NEW BRIDGE.—When one of average imagination, distant foreign travel, and general reading, sits down to write about the last important bridge that has been built in this country, he cannot avoid a dream-like glimpse at bridges everywhere; the natural bridges of South America, with earthquakes for their engineers, contractors, and workmen; the many thousands of primitive bridges in China, formed of huge slabs of stone, brought in many cases from immense distances by human labor; the numerous interesting bridges in France, Germany, Switzerland, and other parts of the continent of Europe, not to speak of the triumphs of this generation's engineers in overcoming almost all conceivable kinds of difficulty in bridge construction that could be presented by climate, materials, situation, or other circumstances in every quarter of the globe. * * *

Blackfriars bridge is altogether formed of wrought-iron so far as the main structure is concerned—the embellishments only being of cast metal. Preparatory to the actual commencement of this important undertaking, the erection of a temporary wooden substitute, as well as the demolition of the old bridge were necessary. The first piles for the requisite gantry—one-third of which is now removed—were driven in, June, 1864. As it is generally considered in the London district that the London clay must be reached to obtain a sure foundation for large buildings, this course was here followed, involving three or four months of incessant daily and nightly anxiety and labor—on account of the tides. For our part, however, we coincide with the opinion of some eminent practical engineers, that there is no absolute necessity for going down to this clay, and that consequently, in doing so, much needless expenditure of time and money is incurred. The bridge consists of five arches, namely, two of 155 ft. span each, two of 175 ft., and one of 185 ft. The height of rise in the center arch is 17 ft., and in the others 16 ft. and 12 ft. respectively. Instead of regularly-framed centring, piles were driven down to support the ribs where required, which doubtless saved the contractor much expense both in erection and demolition. The ribs were then wedged up to the soffit of the arch; these wedges or slacks are now removed, so that each arch rests on its own skew-backs, and the piles can be taken away at once. Mallet's patent buckled plates, which, as most of our readers know, are made of about $\frac{1}{4}$-in. plates of iron placed heated over a mould and stamped by hydraulic pressure into the shape of a groined arch, are bolted to the roadway bearers by $\frac{3}{8}$-in. rivets, and form an immensely strong platform. On this is put one inch thick of asphalte; over this again—an addition to and improvement on the usual practice—a layer of broken stones and asphalte, from 9 in. to 12 in. in thickness, is placed; and lastly, on top of all, is granite pitching as ordinarily laid on roads. The total length of the bridge is 1,272 ft.; its width, including the roadway of 45 ft. and two footpaths of 15 ft. each, is 75 ft. The gradient is 1 in 40. There are eight polished red granite columns, between which there are parapets 3 ft. 9 in. in height. Over each column there are recesses in which there are seats capable of resting ten or a dozen weary pedestrians. A handsome row of lamps will be placed along each pathway, a little back from the kerb—a plan not adopted on any other of the Thames bridges—and they will be so arranged as to facilitate the navigation after dark. The balustrades are Venetian-Gothic in design. They were beautifully cast by Messrs. Lloyd, Foster, and Co., at their works in Wednesbury, Staffordshire, and will form an elegant adornment to the broad York stone pavement. This, with the Thames Embankment, which will meet the bridge at the north abutment on the same level, will form a promenade, on which, no doubt, the ghost of Dr. Johnson will vary his "walk down Fleet-street," and which will prove a source of health and recreation to the pent-up denizens of the City. Viewed from the river, either in ascending or descending the stream, Blackfriars Bridge will present a fine appearance with, as will of course eventually be the case, characteristic groups of statuary to crown the abutment piers, capitals on the polished granite columns, representations of sea-birds and plants on the east, and of their fresh water

prototypes on the west façades, finished by the sky line of the chaste parapet, relieved at intervals by the handsome lamps.

The cost of the erection and maintenance of Blackfriars Bridge will be defrayed from the funds of the Bridge House Estates, the revenue of which is some £40,000 per annum, and to which £21,000 will fall in, in a couple of years, from terminable annuities, on which money was advanced by Government for the building London Bridge.—*The Engineer.*

THE GREAT BRONZE FOUNDRIES OF FRANCE.

From "The Practical Mechanic's Journal."

The casting in bronze, as the chief amongst several metals or alloys by which the artist can endurably entrust the conceptions of his imagination to a remote futurity, mounts as an art to the very earliest yet known origins of our race. China, India, Babylon, Egypt, Greece, Rome, the middle ages of our Europe, the Renaissance, and our own day contribute their monuments or testimonies of this. And yet, in some senses, the art has never spread, or become a diffused or universal one; at this moment there is really but one great bronze-casting nation in the world—France.

England has not been absolutely without attempt to establish bronze-foundries of works of art; but while we have dozens of brass-foundries existing chiefly as integral parts of our great engineering establishments, in which heavy and light bronze or brass castings, for parts of machinery etc., are made in great perfection, there really does not exist, we believe, in Great Britain a single bronze-foundry devoted solely to the speciality of fine-art castings.

Nor are we likely soon to see such, for a great foundry of Bronzes, as objects of high art, demands the combination of two classes of industrial ability, only one of which we, as a nation, can command from amongst ourselves. We must obtain the respective manual skill of the moulder and founder, and, in addition, the hand and eye and genius of the modeler and the metal-chaser; and we may add, above all, that generally advanced and educated standard of taste amongst our people, more especially of the wealthier classes, to appreciate and reward their combined efforts. This combination, of distinct but closely allied and mutually helping talents and powers, can never be broken up and yet success await the issue.

It is for this reason that, while we have had Bramahs (the younger), Robinsons, and Cottams etc., spasmodically attempting the art, and indeed making very fair castings—merely viewed as such—and have had (to say nothing of divers "men in brass jackets") colossal lions, moulded by a painter and cast by a marble sculptor, we have never yet produced a first-rate group in bronze; nor ever established artistic bronze-casting as a fine-art industry amongst us. The Bramahs and Cottams etc., were mere moulders, brass-founders; the Marochettis, whatever they may have been as sculptors, were trading speculators in casting statuary; an art of the refinements and details of which they personally knew nothing, and for the execution of which, in their pompously styled *ateliers*, they were dependent upon the hireling skill of workmen, who well knew the practical ignorance of their employers.

Prussia and Austria—especially the former—have been a good deal more successfull; and almost wholly because they could command the poetry of art, and bring it into the foundry, which we cannot do. And perhaps there is no single modern monument of fine-art bronze-casting in Europe or in the world, at present, of nobler conception and execution than the grand equestrian statue of Frederick the Great, with its surrounding figures and colossal base, on the Linden at Berlin.

Russia, too, has had her long-descended line of first cousins to bronze-founding in the men who cast the gigantic bells of the Kremlin, and her huge old bronze guns; and their descendants have produced some very noble statue-castings, such as the Colossus of Peter the Great, and a good many very finely-cast statues of smaller size, such as the horses and horse-tamers presented to Ferdinand of Naples by the late Emperor of Russia, which are over the piers of entrance to the Palace garden at Naples.

But all these have been spasmodic efforts, sporadic results; in France alone has artistic bronze-casting taken firm root, not as an appanage of despotic extravagance, but as a noble and genuine branch of industry. It would almost seem as if this Roman art had descended to the French, as certainly the lineal successors in many respects of Rome, and the people over the face of whose country Rome spread more widely and

choicely the education and the solid monuments of her civilization, than over any other area in Europe. This, however, would be but a fancy: the expansion and success of fine-art bronze manufacture in France, and, *par excellence*, in Paris, has really been due to the art-loving genius and impressionable imagination of her people, to their art-education, long continued and well understood by those who have conducted it in successive decades; and to the patience and *habileté* of her workmen, supported and empowered by the genuine knowledge and metallurgic science of those who lead them.

On the whole, brass and bronze-founding is much more of a speciality in France, in all its departments, than it has (hitherto at least) ever been in England. We do not make any reference now to Government foundries, such as the bronze gun-foundries of France or of England.

There are, however, in France, great establishments—such as those of M. Voruz, at Nantes—engaged wholly in bronze and brass-founding, and with special departments for artillery, for casting for mechanical purposes, and for statues and other objects of architecture and of art; all being, though of course with the usual fluctuations of trade, kept constantly at work. We are ignorant of a single like establishment in Great Britain. Paris is, however, the great head-quarters of fine-art brass and bronze-casting, and practically supplies the world with its productions.

We view, as out of this trade altogether, the very numerous, and, in a trade-sense, important brass-foundries of Birmingham and its neighborhood, engaged upon small objects for house or domestic or other use, and which profess to have more or less of ornamentation, but certainly have but small pretensions to art, in any worthy sense. Nor do we refer to Japanese bronze and brass work, further than just to remark, that while objects of considerable, some of great, antiquity brought thence formerly by the Dutch, and more recently by ourselves and other European nations, prove that at some anterior epoch, artistic bronze manufacture had reached a very noble perfection, and great peculiarity and often beauty of treatment in design, more modern examples equally prove that the art has greatly deteriorated amongst that wonderful people, or that we now receive from them none of their best examples of art.

No English person who has been a day in Paris can have failed to be struck with the profusion of bronzes in the public ways, in the buildings public and private, and in the shop windows. Bronze-casting is, in fact, a great industry there. There are probably not less than three hundred houses engaged in the trade in one way or other; but of these there are no more than perhaps about fifty who are actual manufacturers, and of these again not more than about twenty who stand in the first rank, of ability and eminence, either as conducting some one or more special branches of the *bronzes des beaux-arts* trade, or the whole of them. But although thus the finished objects of the Parisian bronze-founder arrest the eye and glitter before us at every step upon the Boulevards or in the Palais-Royal, next to nothing is known generally, not even to the technical or metallurgically-skilled visitor to Paris, of the establishments whence these beautiful and costly objects issue, or of the apparatus and methods by which they are produced. They are, in fact, sealed, rigidly shut against all intruders, and for many good and sufficient reasons, which do not admit of being regarded as the mere offspring of narrowness, timidity, or jealousy. One only we need mention. The workmen are, in each of several classes, specialists, in a sense the most absolute, and French employers have found that unworthy and unscrupulous means to detach these men and bring them elsewhere, have been but too often practiced by those to whom the grace of *entrée* may have been accorded.

We have heard, though we do not at all intend to suggest, that, in this way, fine-art bronze-casting in Belgium and in Germany has been very much advanced by the introduction of French artisans.

In Italy most of the workmen, in such establishments as that of Signor Clement Papi, which produced the largest bronze statue, that of the David of Michael Angelo, in 1867 at Paris, are natives; but we believe this is not the case in Prussia, Austria, or Russia.

So far as we are aware, no literature exists which treats in a detailed or practical way of the methods and apparatus of the fine-art bronze-foundry. We shall find none whatever where we might have expected it, viz: in the volumes of Reports of the French Imperial Commission of the Exhibition of 1867, or, indeed, in the reports of any preceding one. The reporter for 1867, on class 22 (Vol. III, of the collected

reports) was M. Barbadienne, the man who perhaps, above all others, *could* have given us a complete and invaluable treatise upon the technicalities of this manufacture, in which he has so long and so conspicuously led the advance. We look for any such details in vain; not that we imagine M. Barbedienne felt the slightest desire or ground for reticence, but that the space assigned him in these volumes as a reporter was far too restricted to admit of his dealing with more than mere generalities; indeed, the whole 500 pages of Vol. III might prove less than enough to enable, one at once so skilled in every detail, æsthetic and technical and so enthusiastic, to pour forth the treasures of his knowledge upon this speciality, in which he so admittedly leads.

Where no literature exists, therefore, a sketch may be accepted as a not unwelcome installment. Such we are enabled to give, the writer having been recently accorded by M. Barbedienne himself the unusual and special favor of the unreserved examination of his noble foundry and manufactory at Paris.

There are, no doubt, half-a-dozen fine-art bronze-foundries in or about Paris, the description of any one of which would prove interesting. That, however, of M. Barbedienne stands amongst these *facile princeps*, and indeed is not one, but, so to say, a congeries of special manufactures. The works are situated in the Rue de Lancry, at not a very great distance from the well-known "show shop" of bronzes, as our homely phrase is, No. 30 Boulevard Poissonnière. It is, however, happily placed, though still upon the edge of that quarter of fashion, traffic, and pleasure, also upon the border of that wonderful north-east quarter of Paris, which, like our own north-east of London, is the seat of so many of its myriad industries, and which, as respects the French capital, is a *terra incognita* to ninety-nine out of the hundred Englishmen who visit that city, or even reside in its fashionable quarters.

Entering from the street, we pass through a range of offices, waiting-rooms, packing-rooms and stores, and find ourselves crossing a yard, and at once in the large bronze-foundry.

The establishment comprises, in fact, the following departments if we may not almost call them distinct manufactories:

1. The bronze-foundry and its accessories.
2. The chasing-shop—*galerie des ciseleurs.*
3. The shops for the production of models, and for the completion of a large number of these in the permanent material bronze.
4. The marble work; a complete establishment for the working, both by machine tools and by the sculptor's hand, of all sorts of marbles, onyxes, and other fine and hard minerals.
5. The shops for mounting of Carcel lamps and other objects of artistic bronze work in combination with porcelain, glass, etc.
6. The enameling shops, in which that peculiar form of "*émaux cloissonnés*" which, dating from Byzantine art originally, had been lost to practice for ages in Europe, though always employed in China and Japan, and were revived in France by M. Legost, in 1855, and greatly extended by M. Barbedienne.
7. The "*atelier*," in which the delicate and beautiful machinery of M. Collas is worked for the automatic reduction or enlargement of solid forms.

This machinery is constantly employed in the production of new models for bronzes, etc., whether figures or bas-reliefs, etc., and of every size. It constitutes, as M. Barbedienne has himself affirmed, the right-hand of the bronzist, enabling him not only to reproduce the forms of ancient art with rigid exactitude, but to copy them equally so to any scale, and at an extremely small cost.

Were it not for this machine-tool, it would be impossible, at any reasonable prices, for M. Barbedienne to quote in his catalogue sometimes as many as eight different sizes for the same reproduced antique statue, and to have at command five or six sizes in bronze of nearly all the celebrated statues, ancient or modern, which enchant the world.

M. Collas' machinery gained him, and we believe very justly, the grand medal of honor at Paris, in 1855. Its rudiments, however, are very ancient, and to be found in many an old book on turning; and in reality we believe there is little doubt but that all which M. Collas has effected was done, and thoroughly well done, by Cheverton in London as early, perhaps, as 1830; as those who have seen, or are happy enough to possess, specimens of his matchless reproductions to a reduced size, in ivory, of the antique bust of Clytie, must be aware. Cheverton, however, worked his machine in secret in his chamber, and would not divulge its details, and we believe died without hav-

ing ever fully and publicly claimed to have been its perfector.

What degree of similarity there may be between both we cannot say, but all machines of this class in reality depend upon the use (more or less implicated, of course) of a lever, the ratio of whose arms is variably at will, one end of which carries a dumb point which traverses, in closely and equally adjacent parallel lines, over the contour to be copied; while the other end, guided by that, carries the revolving or other cutting tool which removes the brute matter from the mass, to be formed into the reduced, or equal, or enlarged copy, and can remove no more.*

8. Besides all these there are "mounting shops," where the bronze pieces are connected, either with precious marbles or stones, or by "*menuisiers-ébénistes*" with fine cabinet work.

Subsidiary to all these there is a grand gallery or store, for porcelains, Indian, Japanese, French, English, etc., to be employed for divers ornamental ends in combination, and a whole tribe of small shops for the preparation and repair of tools, etc., etc. We need scarcely say amongst these are "drawing shops," artists' studios, in fact, where the imaginative brain labor that inaugurates much that follows, is in full play on the part of architectural and sculptural draughtsmen, and other artistic "*coopérateurs*" of the establishment.

Let us return to the foundry and its adjuncts, of which we can describe much to interest our readers, without any breach of the confidence reposed in us, as visitors to these famous works.

The foundry is a very large rectangular brick building, whose sides are about twice the breadth. It is lighted by ample skylights in the roof, and we at once notice the perfect cleanness of the walls and roof, and the nice clear pearl-white with which the brick of the former is colored, so as to afford the best light without distress to the eye. There are no piles of rubbish about, neither spare-boxes, nor unused models; all is orderly, a picture of neatness.

The floor, with the exception of some gangways, is of loamy sand, and ready in heaps beside each moulder.

The greatest proportion of the work being small, or very small, so the whole (nearly) of the moulding work is done on benches.

These occupy a large proportion of the whole area, and are arranged transversely to the length of the building in parallel ranges, with an axial gangway passing right through, and dividing them along the center. Each bench is double, *i. e.* two benches and two sets of moulders face each other at work. Each bench varies in width from 3½ to perhaps 5 feet; and the mid-line of separation between the opposite benches of the same double bench is occupied by a raised division, with a low table or shelf on top to hold tools.

By far the greater portion of the work is moulded "in dry sand," the large statues being in true "loam work," but "green sand" moulding for small, plain, or unimportant objects is also largely practiced.

At one side of the "*salle*" is the place where the sand is prepared, mixed and damped. The sand employed is of two qualities, one being of a deep brown color, and very loamy; the other of a very light yellowish-white, with more yellow particles *parsemé*. Both are obtained at Fontenay des Roses, not far from Paris to the northwest. The two sorts are mixed, first, by interstratefying them in alternate layers in heaps, the relative thicknesses depending partly on the class of work the sand is being prepared for.

These zebra-striped heaps are then cut down with the shovel, and the whole set between a pair of very fine set horizontal cast-iron rollers. The sand is finally, after being damped to the right degree, sifted, and so handed over to the men. The "*chassis*" or moulding-boxes are all of cast-iron, very carefully fitted together, and with well-planed edges. We did not see a single wood-box* (so common even now in British brass-foundries), nor any makeshift of any other sort about the establishment.

Wood patterns or models also are but little employed, except for objects to be finished in the lathe. The models are chiefly of bronze, carefully chiseled or chased up, and given a dull brownish-grey sort of "patina," which seems to enable them to part from the sand with very great cleanness. Plaster casts, fusible metal, wax, and even occasionally porcelain or glass come into play as models also. All the bench moulding-work is of a character demanding great care, dexterity, and patience. The latter quality, as well as steadiness of hand and perfection of vision, find their greatest demand with the moulders who are engaged in casting objects which are to form the basis for the *émaux opaques et cloisonnés*.

* Blanchard lathe.

* "Practical mechanic's" name for "flask."—Ed. V. N.'s Mag.

Our readers generally are, no doubt, familiar with the character of these from seeing the like objects exhibited in Chinese and Japanese collections. The design, always of a stiff and conventionalized character, is outlined, as it were, and its distinct portions divided by very thin walls of bronze, mere lines almost, which rise square up from the general surface of contour of the object, and to a height equal to the depth of the intended coat of enamel, which is very thin, not more even than a millimeter, seldom more than half as much. Thus, in fact, the enamel when baked in, is held fixed in so many shallow bronze-surrounded cells, the dividing and adjoining edges of which are polished off bright, at the same time that the enamel is ground off to a uniform surface. This little digression may serve sufficiently to explain the nature of *émaux cloissonnés;* and into the details of the compositions of the enamels themselves, and how applied and completed, we do not here purpose entering.

It will thus be seen that the very utmost importance attaches to casting these little *cloisons*, or cells, perfect; any morsal of bronze improperly filling a portion, however slight, when cast, has to be cut out by hand, and at some risk of damaging the thin low wall of the *cloison* itself.

It is almost painful to watch the lynx-eyed patience with which the moulder of one of these objects—say, a huge vase of three feet in hight, covered all over with thousands of these cells—finishes each, with minute almost microscopic hand tools, after he has "drawn" the bronze pattern. The value of this is represented mainly by the money consumed in payment for the design, the original wax and plaster model, and the casting and hand-finishing of this workable bronze pattern; such patterns are laid aside on cushions, and kept covered carefully.

We shall not devote space to describing the considerable system in operation for the organization, registration, preservation, cleansing, and return into store, of the innumerable patterns. The law of copyright, which in France is far more protective and precise than it is with us, has greatly relieved such men as Barbedienne of one of their anxieties, viz: that of having their design stolen, or their models bought for patterns by others; still, the *chefs d'œuvre* are guarded with care.

The facing sand of the moulds, whether dry or green, is prepared with a mixture of charcoal dust and of potato starch, or of wheaten flour of the very finest grinding. In the preparation of these each moulder takes his own way, and there appears to be as much whim and variation here, as amongst iron-moulders. Sand cores, amply hollowed for air, are employed for all hollow objects, not of large size or not cast in loam; for the latter, the cores are also of loam. In statue-casting it is deemed of high importance to the final perfection of form when cast, that the thickness of the casting should be perfectly uniform. This arises chiefly from the great contraction in cooling (from 1 to 2 per cent) of bronze, and the prolonged state of plasticity through which it passes between the liquid and solid states. Hence, if there be thick parts as well as thin, the latter solidify so completely before the former that the thick parts get more or less distorted. The distortion may be utterly invisible to the undisciplined eye, but that of the artist-workman here readily detects and finds fault with a change of form in the muscles of a "*Discobalus*" or a "*gladiator*," or in the voluptuous rounding of the limbs of a "*Vénus accroupie*" or "*de Milo*," which the world at large cannot discern.

The contraction of cooling is found to augment in ratio, with the size of the object cast, being greatest in large statues. For all these reasons, the utmost care and some very refined, though simple, methods are employed to ensure that "the core" shall be in form precisely similar to the exterior of the statue or figure, and that it shall be placed and fixed in the mould with rigid concentricity. It is the opinion of M. Barbedienne, which he has expressed in his Jury Report (Class 22) of 1867, that wheaten flour is not so good a facing material as charcoal dust; but he deems that much remains to be learnt as to the best material for facing bronze sand-moulds, and hesitates not to say that no moulder now-a-days succeeds in attaining an equally *fine and uniform granulation* of surface as was habitually produced by some of the great bronze-founders of older days, such as Richard, the Ecks, Durand, and the brothers Keller, who cast so much for Louis XIV.

It is also worthy of memory how fully M. Barbedienne insists upon the primary importance of perfection in the moulding and casting. Most persons would say that an object which was to pass into the hands of the "chaser," or *ciseleur*, might be cast as rough as we please, and yet all its faults be

remedied in the metal-sculptor's hands. Skilled experience says no; it even goes so far as to say, if the work come out of the sand perfect, the less the "chaser" does to it afterwards the better; and, in fact, M. Barbedienne boldly attributes the matchless beauty of many antique, or even middle-age bronzes, to the fact that in these, the same mind, eye and hand carried through the entire process, from the conception of the model to its completion, thence to the moulding and casting, and finally to the chiseling and dressing, and to complete finish.

This seems to have been true in some cases at least, if not in general. The exquisite bronze statuette of the young man, found about five years since at Pompeii, which has been called, though on no sufficient evidence, "the Listening Hunter," and which is undoubtedly one of the finest reproductions in the world, to reduced scale, of the youthful male form, as well as several of the great *relievo* castings of mediæval Italy, in gates and well ("*pozzi*") curbings, are cases in point.

But to return; at the end of the foundry, furthest from the entrance, are the furnaces, the stove for drying the moulds and cores, of which we need say nothing but that it is heated by the waste furnace-heat, and a large wrought-iron jib crane for pitting and unpitting boxes in which large objects are cast.

The bronze for all moderate-sized objects, say up to 250 kilos., is melted in clay crucibles, which are made in the neighborhood of Paris, and hold about 30 kilos. each. These are not extremely refractory, but stand three or four meltings.

There are eight crucible furnaces, in form very much that of the ordinary brass furnace, but differing from usual practice, in England at least, in that they are not wind furnaces, but are fed with blast, from a small fan (about 20 in. diam.), driven by a strap from the engine of the "*manbrerie;*" the fuel is coke, and the advantages seem to be patent of this arrangement. The metal is "brought down," *i. e.* melted, very much faster, the "heats" can be repeated much more rapidly, and the consumption of coke is greatly less than with wind furnaces. Then again, when the crucibles are about to be "drawn," the blast is thrown off, and there is much less flare and heat to be endured by the man who lifts them out. The tops of these furnaces are of cast-iron, the covers of iron-bound square fire-tiles, and the tops are about 22 in. above the floor level.

The large air-furnace is fed with dry wood fuel, and will melt upward of 1,000 kilometers.

In older times statues were always cast in a loam-mould, put together piece by piece in the excavated pit, and, as fitted in place and jointed up, the pit was rammed up round them. This was but a make-shift mode, and had several serious evils: the mould never could be dried with perfect uniformity; and even when dry, it stood so long in the pit while being got ready, that it imbibed moisture anew, and hence so many "mis-casts" of old. Under the heavy head of liquid bronze, too, the ramming-in of the pit sometimes proved soft and deceptive, so that here or there the walls of the mould partially bulged, and the casting was either lost or damaged.

All M. Barbadienne's statues or large objects are cast therefore in cast-iron flasks or boxes, so that the pit is what iron-founders call a "naked pit," *i. e.* no ramming-up is practiced.

A "pool" or reservoir of sand with charcoal facing, is employed for all large castings, into which the contents of the crucibles are "teemed," or into which the air-furnace is tapped. When the full quantity of metal is in the pool, an iron conical plug, which had been inserted into and stopped the main "gait" or "*coulée*," is drawn up, and the metal enters the mould.

It passes off (as overplus) by "rising heads," as in cast-iron moulding, and "the gas is fired" at these, by a lighted torch in the same way. From the low temperature of the liquid bronze, however, as compared with cast-iron, but a small volume of gas is evolved from either moulds or cores.

The head of surplus pressure employed is always very small, for fear of distortion; a practice exactly the reverse of that of bronze-gun founding, where the "*masselet*" or "rising head" is often nearly as long as the gun itself above its muzzle, which is uppermost in the mould. It may be very much doubted, or even on plausible grounds contested, whether any advantage is obtained by these very long "gun heads," and whether some positive evils in the increased segregation of the alloy be not thus introduced. Bronze-gun founding, however, is now, in these days of huge wrought-iron artillery, somewhat an art of the past, it

may be said. We must remember, however, that Prussia is returning to bronze rifled field-guns, and that our new rifled Indian artillery is also to be of bronze.

The metals employed by M. Barbedienne for his bronze are very pure "tile pitch" copper, and English or Straits tin, also of best quality. The copper is usually South American, again melted in France, purified by "liquation," and run into small pigs of about the size and form of ours known as "Best selected copper."

A proportion of bronze from "gaits and runners" is usually added, but the composition of this is *quam prox.* already known and constant, and its material is unadulterated, so no mischief can arise. No *old material*, whether copper, bronze or brass is ever employed; and the *directeur du travail*, who so intelligently and politely showed us round the works, and explained their methods with the lucid brevity so characteristic of the higher *contre-maitre* of France, expressed his opinion that it was impossible ever to cast a first-rate statue or relief, especially of large size, from old bronze guns, or other old material of variable composition. He instanced many proofs of this; and, undoubtedly, the porous bad castings of the reliefs of the Napoleon Column in the Place Vendôme, of the statue of Desaix, etc., at Paris, and of our own Trafalgar Square lions seem to sustain this view.

That bronze ornamentation is not more widely diffused in Europe generally, and that it is so prevalent in France, arises from two main causes. Fiscal or custom-house regulation of absurd severity in the case of all the European nations; and on the part of the United States, and as respects ourselves, want of diffused good taste or perception of beauty in form, either in the interior or exterior of our public or our private buildings or national monuments.

For 100 kilos. of bronze, on entering the frontiers of each of the following nations, the duties are thus:

	Bronze.	Bronze gilded.
Russia	377 francs	470 francs.
Austria	250 "	250 "
Spain	155 "	155 "
France	20 "	100 "
Italy	17.17 "	100 "
Switzerland	16 "	100 "
Prussia	13.10 "	112.50 "
In United States	350 francs on	1,000 francs value.
Belgium	100 " "	" "
Holland	50 " "	" "

England and Portugal alone admit bronzes free.

The *bizarrerie* of these figures forms a curious commentary on the wisdom of finance ministers everywhere.

We must, however, reserve to a future article some further remarks upon these works for bronze, and upon ornamental zinc and iron castings, which follow humbly in its steps.

SEA-GOING TURRET-SHIPS.

From "The Practical Mechanic's Journal."

The completion, at Chatham, of the Monarch affords a fitting opportunity for a few remarks on sea-going turret-ships. It is well known that the earlier turret-ships of our navy—the Royal Sovereign and Prince Albert—are really coast-defense ships, since they have only a minimum of sail-power, and are so badly supplied with coal as to limit very narrowly their steaming capability; for coast and harbor defense they will, however, prove useful, should their services ever be required. Besides these, we have in our navy the far-famed Scorpion and Wivern, built by Messrs. Laird during the American war, and purchased by the Government after they had been for some time in the custody of the authorities on suspicion of being intended for the Confederates. Perhaps no vessels have ever attained a reputation more disproportionate to their real powers of offense and defense than these two ships; for, although thinly armored and but weakly armed, they have been frequently described as most formidable vessels. We do not, however, propose to discuss the merits or demerits of those ships, but simply to add respecting them that, although intended to keep the sea, and therefore provided with a moderate amount of sail, they have proved very inferior seaboats, the Wivern having particularly distinguished herself by excessive rolling. The advocates of the turret system have always argued that the bad performance of these ships was in a great measure the result of their moderate size (they being of less than 1,900 tons burden), and have urged the desirability of bringing the turret system into competition with the broadside system in ships which, in point of size, could compare with our armored frigates; this trial will be rendered possible very shortly, when the Captain and Monarch are complete for sea. It would, of course, be folly to predict exactly what results will be obtained; one

thing, however, seems certain, viz: that, as sea-boats, both of these vessels will prove far superior to any existing turret-ships; and there is every probability that the Monarch, if not the Captain also, will prove as efficient under sail as our broadside iron-clads.

Although classed together as sea-going turret-ships, there are some very great differences between the Captain and the Monarch. The former, we need hardly say, is supposed to be the fullest expression of Captain Coles' ideas respecting ships of the class; the latter was designed in the Controller's Department at the Admiralty, and must, therefore, be regarded as the representative ship of the type of which the naval officers, then at the head of our navy, most approved, and which the professional officers did their best to perfect. Looked at by an unprofessional spectator, the Monarch presents no special feature; she has the lofty sides and upper deck of a broadside ship, and is rigged in the usual manner. In fact, in all respects except the turrets, and some special arrangements of flying or hurricane deck for carrying boats, consequent upon the turret armament, the Monarch closely resembles the broadside ships which immediately preceded her. What would be the central battery on the main deck—if she were a broadside ship—is the space in which the turret-beds are built; and there are, of course, no port-holes in the side armor. On this central space or battery the armor rises to the height of the upper deck, about 14 ft. above the water; before and abaft it there is an armor belt, extending throughout the length, and reaching from about 5 ft. below the water-line up to a nearly equal distance above it. Instead of this, the Captain has her upper deck only 8 ft. above water, and throughout the length the armor reaches from a few inches below this deck down to about 5 ft. below water. She has a poop and forecastle above the upper deck, and a flying deck extends along the length between, this light deck being comparatively narrow, and being intended, unlike that of the Monarch, for working the sails. The Captain has tripod masts. Her turrets pass down through the upper deck, and the beds are built upon the deck below; the guns are, therefore, only about 9 or 10 ft. above water, while in the Monarch they are 15 or 16 feet. This is, doubtless an advantage of considerable importance in a ship like the Monarch, intended to fight in a seaway, since she could use her turret-guns when the Captain would be powerless; but this advantage has been purchased at a considerable cost. First of all, the Monarch is 800 tons burden more than the Captain, although she only carries about the same weight of turrets and guns as the Captain, and has armor of the same thickness; the different disposition of the armor in the Monarch requiring a much greater weight of armor than the Captain's system would require, and the lofty sides, of course, adding to the weight of hull. Then the Monarch, being a larger ship, has a greater weight of equipment, heavier and more powerful engines, and a greater weight of coal than the Captain, all of which, of course, must be regarded as the result of the difference of types. The side armor of the ships is nearly all 7-in.; the Captain has a little 8-in. in wake of the turrets. On the turrets the armor is 8-in. and 10-in., the greater thickness being used near the ports. The turrets, of which there are two in each ship, will each carry two 25-ton guns, throwing 600-lbs. shot. Besides these the Monarch has three 6½-ton guns, two of which are in an armored bow-battery, and the third in an armored stern-battery; the Captain has two 6½-ton guns, carried unprotected on the poop and forcastle.

In conclusion, we would remark that the turret system is at a great disadvantage when applied in a full-rigged sea-going ship like the Monarch or the Captain. By means of poops, forecastles, stays, shrouds, tripods, or other obstructions, it becomes impossible to fire the turret guns in very many directions, and hence the chief merit of the turret system—an all-round or nearly all-round fire—is forfeited. Direct fire, either ahead or astern, both of which are most important, is entirely out of the power of the turret guns of both ships; the Monarch, by means of the bow and stern batteries, making up for this failure to some extent, while the Captain is the most unsatisfactory of our recent ships, in so far as what are termed "arcs of impunity" are concerned. In fact, no greater contrast between ships can exist than that between the Captain, which has no power of firing within, say, 15° of the line of keel either ahead or astern, from her turrets, and the broadside ships of the Invincible class, which, from armored batteries amidships, can command an all-round fire. In this most important respect the broadside-ships have completely outstripped the turret-ships.

CHURCH'S EQUILIBRIUM SLIDE VALVE.

From "Engineering."

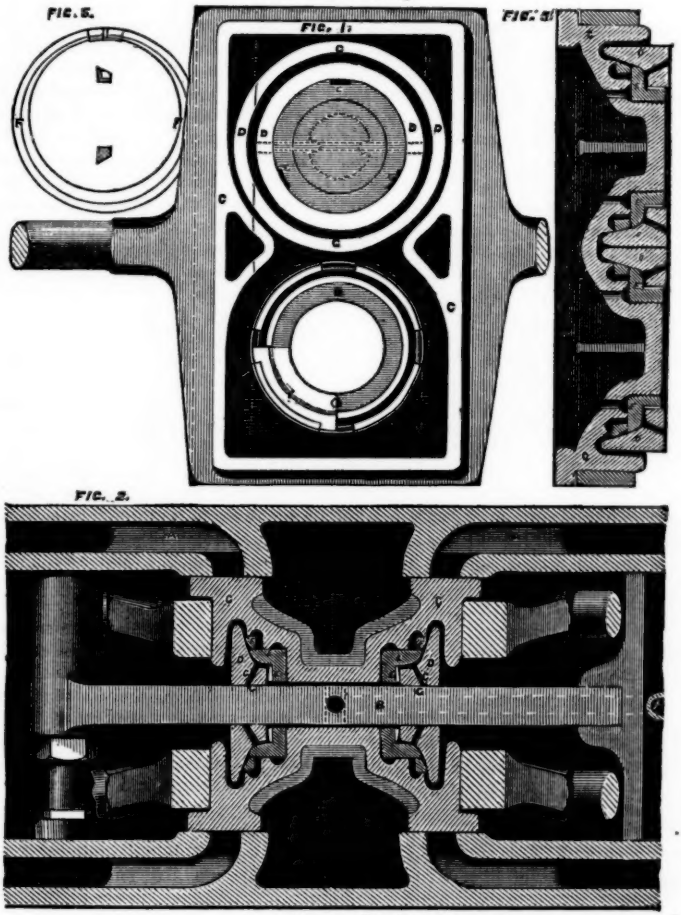
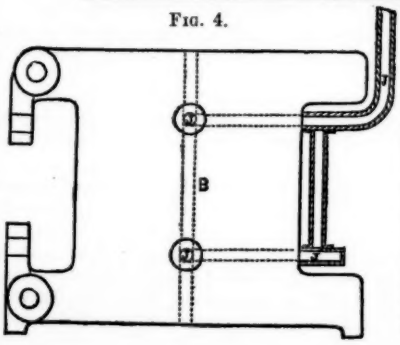


FIG. 4.



In the course of our account of the Conversazione recently held at the Institution of Civil Engineers, we mentioned a pair of equilibrium slide-valves, designed by Mr. W. C. Church, and which were exhibited on that occasion. In fulfillment of a promise then made, we now publish engravings of Mr. Church's arrangement, which will explain it fully. The particular pair of valves shown, on the occasion above referred to, had been taken for exhibition from a locomotive on the Great Northern Railway, on which line they had run up to the time of their removal 740 miles; and this trial, although not a long one, gave very promis-

ing results. The valves have, we believe, since been replaced in the engine to which they belong, in order that they may undergo a more extensive trial, and that the saving of fuel, which is obtained by their use, may be accurately ascertained; and we hope in due time to lay the full particulars of this trial before our readers. In the meantime we may remark that Mr. Church's equilibrium slide-valves, although at first sight apparently rather complicated, are in reality of simple construction. There are but few parts about them, and the pieces are all of such forms that they can be finished in a lathe, scarcely any hand labor being required to fit them together. The whole of the details, moreover, bear evidence of having been carefully considered, as the description of the arrangements which we shall now proceed to give will show.

Referring to our engravings, fig. 1 is a back elevation of one of the slide-valves we have mentioned, this valve being constructed for two caps or rings, D D, of which the object will be explained presently. In the figure one cap is shown in its proper position, and the other removed, showing a quarter of the junk ring. Fig. 2 is a vertical section through the steam chest, and fig. 3 is a section at right angles to fig. 2. Fig. 4 represents, detached, the division plate, with the pipes for carrying off any leakage of steam between the backs of the valves and the insides of the caps. Fig. 5 represents the metallic packing-ring detached. In these figures, A A are the steam-ports, B the division-plate, C C the slide-valves, D D the caps or rings applied to the back of the slide-valves, E E the junk rings, F F the metallic packing rings for keeping the caps, D D, steam tight.

In considering the action of Mr. Church's valves, it must be understood that the object of the caps is to prevent the steam in the steam-chest from acting on those parts of the back of the valve which are enclosed within the caps, or, more strictly speaking, those areas which are represented as enclosed by the lines of contact between the caps, D D, and the metallic packing rings, F F. It will be seen from the section of the cap (figs. 2 and 3), that the latter is of a conical form, both internally and externally, the object of this form, internally, being to enable the metallic packing ring, F, to act as an expanding ring, in order to press the cap up to the division-plate, B, when the steam is shut off from the steam-chest. The circular grove, G, and the holes, G^1, in each cap, D, and the holes, E^1, in the junk ring, E (seen best in fig. 1), are intended to carry off all steam that may leak between the surface of the cap, D, and the division-plate, B (or second valve, as the case may be), at a part of the cap that will prevent the occurrence of a pressure to remove the cap, D, from off its bearing face.

It will be seen that when the steam is in the steam-chest, the cap, D, is pressed up against its bearing face by the steam acting on an annular area, the width of which is equal to the difference in diameter between the metallic packing ring, F, and the cap, D. The caps, D D, are free to move on a fixed center, at a point, H, so as to compensate for unequal wear of the valves or the cap face, or for one side of the valve to lift in case of the engine priming. This is a feature in Mr. Church's arrangement which is worthy of special notice. The metallic packing ring, F, is also arranged in such a manner as to be capable of accommodating itself to the varying position either of the cap or valve. The said ring is so arranged that the steam presses it both outwards against the cap, D, and upwards against the junk ring, E.

The metallic packing ring, F, is also made conical on its outer circumference, for two reasons: first, in order to reduce the area of superficial contact between itself and the cap, D, and, secondly, in order to give the steam a larger area to act upon at the bottom of the ring; so that no amount of leakage on the top of the latter shall be able to place it in equilibrium, and thus destroy its required action. The holes, passages, and pipes, J and J^1, in connection with the division-plate, B, are intended for carrying off any steam that may accumulate in the cap, D. The pipes, J^1, are in communication with the atmosphere, and are furnished with cocks, so that in the event of any accident occurring to the caps, D D, these cocks can be closed; the effect of which will be merely to alter the action or condition of working of the valves, and reduce them to valves of the old construction, a great practical convenience.

The division-plate, B, is adjusted in position as required at the back end of the steam-chest, by means of set screws, as shown in fig. 2, and at the front end by means of two brackets fixed to the steam-chest lid, so that when the steam-chest lid is removed, the valves can be withdrawn in

the usual way without disturbing the division-plate. Another mode of fixing the division-plate is to slide it into a groove provided for it in the top and bottom of the steam-chest. We should also mention that in one arrangement of his valves, Mr. Church employs no division-plate at all, but lets one valve work on the back of the other, and he at the same time arranges the steam ports so that the passages leading to the cylinders are much shortened. The adoption of this plan, which possesses several good points, of which we may speak more fully on another occasion, of course renders special cylinders necessary.

Mr. Church gives the following rule as that which he employs to determine the area of the cap or caps to be applied to the back of the valves.

"That portion of a slide-valve which does not leave the face of the ports at the end of the stroke, less the area of the steam ports, represents the area on the back of the valve, upon which there is a constant pressure, varying only with the pressure of steam in the boiler. And as it is the object of these improvements to remove this pressure, it becomes desirable to point out the following rule for determining the area of the back of any slide-valve, from which the said pressure may be removed, by the application of a cap or caps, as hereinbefore described. Let A equal the area of that part of the valve that leaves the face at the end of the stroke; C the total area of the steam ports; D the area of the annular cap or caps, for removing the pressure from the back of the valve. Then the formula will stand as follows:

$$A - (B + C) = D.$$

"To take an example—Let a slide-valve be supposed measuring $11\frac{1}{4}$ in. by 19 in. The total area of the back of this valve would be equal to 213.75 sq. in. The area of that part of the valve which leaves the port faces at the end of the stroke may be taken in this case as equal to 43.75 sq. in. The total area of the two steam ports is equal to 49.50 sq. in. Then $213.75-(43.75+49.50)=120.50$ sq. in.; which shows the area of the cap or caps to be applied to the backs of the valves, or, more strictly, the area to be contained within the circle described by the line of contact between the cap or caps and the elastic metallic packing ring."

WHO INVENTED THE STEAMBOAT?

From the "American Artisan."

The question of who invented the steamboat could be correctly answered only by enumerating several projectors whose efforts succeeded each other during a period of three-fourths of a century. The propulsion of boats by paddle-wheels is said, indeed, to date back to the time of the Romans, but precisely in what way they applied the power is not known. As long ago as 1682, Prince Rupert, the courtly mechanician of the heyday of the Stuarts, propelled his barge in this way. In 1726, one Dr. Allen printed a pamphlet in London, in which he proposed to urge a vessel forward by a jet of air or water ejected from a pipe at the stern. He thought that by using steam power he could make three miles an hour in this way. In 1737, Jonathan Hulls published his invention, which may be considered the archetype of the modern steamboat. It had a paddle-wheel arranged at the stern, and worked by a steam-engine; but instead of the crank, the application of which to the steam-engine had not then been invented, Hulls employed a complicated set of devices for giving motion to the wheel. After this there was little or nothing suggested in the line of steam propulsion until 1782, when the Marquis de Jeoffroy tried a steamer on the river Loire in France. Instead of a paddle-wheel, he had the paddles arranged upon an endless belt that traversed two supporting pulleys, but the apparatus was not successful. Two years later, James Rumsey commenced experiments with a boat 80 ft. long, in which an engine worked a vertical pump that drew in water at the bow and ejected it at the stern. The reaction of the effluent water moved the vessel along at the rate of four miles an hour. This seems to have been a revival in some sort of Allen's plan; and substantially the same system has been frequently re-invented since, a recent and notable example of these jet-propellers being found in the English vessel, the Water Witch. In 1786, John Fitch made public his project of moving vessels against wind and tide by fitting them with vibratory paddles worked by steam-power. There were twelve paddles, six on each side of the boat, one-half of these on either side working alternately with the other half of the number. The paddles were designed to have a stroke of $5\frac{1}{2}$ ft., but it does not appear that the plan

was ever subjected to actual trial. Fitch, however, did not rest content with this plan, else he would never have been heard of afterward, but was also the inventor of the screw-propeller, and also of the combination in one vessel of the screw and side-wheels—the principle of propulsion adopted in the Great Eastern. This screw-propeller, and mode of using it in connection with paddle-wheels, was shown by experiment, in 1796 or 1797, on the collect Pond, a sheet of water that in those days rippled where the grim Egyptian pile, the New York City "Tombs," now stands. The vessel is described as a common long-boat, 18 ft. long and 6 ft. wide, and steered at the bow. The steam-boiler was constituted by a twelve-gallon iron pot, with a lid made of a piece of plank firmly fastened down. The engine had two wooden cylinders, and the mechanical appliances for working the screw and paddle-wheels, although rude, were arranged with such effect that a speed of six miles an hour is said to have been obtained. The inventor, however, was too poor to continue his experiments, and too impatient of argument and contradiction to interest incredulous moneyed men of the day in his enterprise. The boat, with a part of its machinery, was drawn up and left on the shore of the pond, and piece by piece this type of the future steam-vessel fell to decay, and the children of the neighborhood gathered up its fragments and carried them home for kindling-wood. A few years later, Fitch, a broken and embittered old man, with feeble health and ruined fortunes, poisoned himself with opium, and was buried in Bardstown, Ky. To this day no monument or head-stone marks his resting-place, but the fulfillment of his prophecies is shown wherever the steam-whistle sounds over the placid waters of rivers or the turbulent foaming of the sea.

While Fitch and Rumsey were thus experimenting with steam propulsion, others were making trials in the same direction, with more or less success. As an illustration of the blunders that even truly great men will sometimes make, it may be noted that about the year 1786, Dr. Franklin proposed to propel vessels by the direct action of steam upon the water, which was, of course, found to be utterly out of the question. About the same time, Oliver Evans advocated the employment of paddle-wheels, and a boat was run for a short time between Philadelphia and Bordentown, but no details of its means of propulsion have been handed down. In 1787, Mr. Patrick Miller, of Dalswinton, in Scotland, made a double vessel, moved by a paddle-wheel at the stern, and two years after constructed another, 60 ft. long, that went at the rate of seven miles an hour, but proved too weak to bear the action of the machinery. It is said that these experiments cost Miller upwards of $150,000, for which he received no return whatever. A dozen years afterwards, William Symington, who had made the steam-engines for Miller's boats, induced Lord Dundas to build a steam-vessel for towing craft on the Forth and Clyde canal. This, the Charlotte Dundas, dragged along two sloops of 70 tons burden each against a strong head wind at a speed of 3½ miles an hour. The owners of the canal, however, refused to use this means of towing, because of the liability of injuring the banks by the undulations of the water—the principal reason to this day why steam has not been applied in canal propulsion. From this time forward steam navigation began to assume a more promising aspect and more tangible shape. In 1804, John Stevens, of Hoboken, N. J., had a boat 24 ft. long, fitted with a paddle-wheel at the stern, which, for short distances, made eight miles an hour. The greatest benefit, however, conferred by Stevens upon the engineering world was in the invention of the tubular boiler—a principle of construction that has worked wonders in steam-generators for all purposes.

We now come to the efforts of Robert Fulton, a man who possessed business talent, and the faculty of mastering the details of whatever he undertook, in a no less degree than inventive skill. He left Philadelphia in 1786, and went to London, where, as early as 1793, he communicated with Earl Stanhope concerning steamboats—this nobleman being something of an enthusiast on the subject, and having a plan of his own, which has come to be known as that of the duck's-foot propeller. This was simply a kind of folding oar, which opened to act against the water when pushed outward, and closed when drawn back at the end of the stroke. After this Fulton went to France, where he brought before Napoleon a method for blowing up the English ships; but although he made an apparatus by which he was enabled to remain under water for a period of 4½ hours, he did not destroy a single vessel of the enemy. His journey to France, however, did him some good, for it

was there that he became acquainted with Chancellor Livingston, who furnished the funds by which he was finally enabled to put his plans for steam propulsion into practice. Assisted by Livingston, he, in 1803, made experiments on the river Seine with a paddle-wheel boat 60 ft. long. The results were so favorable that it was concluded to attempt, without delay, the introduction of steam navigation on American waters. An engine was ordered from the English workshops of Boulton & Watt, and was duly forwarded to New York. In 1807, the Clermont was launched on the East River, and at once commenced running on the Hudson, between New York and Albany. Since then, until the present hour, there has not been a single day when vessels have not been propelled against wind and tide by the power of steam—the Clermont having been, if not the earliest practical steamboat, at least the first steam-vessel to establish a system of regular trips between different places.

METROPOLITAN RAILWAY ROLLING STOCK.

From "Engineering."

A few weeks ago there appeared in a contemporary* an article on the rolling stock now in use on the Metropolitan Railway, this article containing what was professedly a comparison of the stock belonging to the Metropolitan Railway Company proper with that employed by other companies running trains over the Metropolitan line. The deductions drawn from this comparison were so startling, and in some respects so at variance with our own ideas on the subject, that we determined to investigate the matter further, and the result has been that we have, as we anticipated, discovered in our contemporary's article many grave mis-statements of facts which, in common fairness to those by whom the Metropolitan rolling stock was designed, deserve to be exposed. And here we may remark that although, in the instance we have referred to, we consider that the rolling stock of the Metropolitan line has been most unjustly criticized, yet we are by no means desirous of having it supposed that we consider the stock, as a whole, perfection. With the engines we consider that little or no fault can justly be found. They are in all respects thoroughly well adapted to the exceptional work they have to perform; their construction is such that their working expenses are very moderate; and, as we shall show presently, their weight is in no way excessive when all the circumstances of the case are taken into consideration.

With the carriages the case is somewhat different. Their weight (16 tons each empty) is no doubt too great even when the excellent accommodation they afford is taken into consideration; but in speaking of this weight it must be remembered that it was incurred under exceptionable circumstances. Before the Metropolitan line was opened were many who affirmed—and apparently with a certain amount of reason—that it would never be a success. It was asserted that the public would never "take" to an underground line; that they would object to travel to and fro, shut out from the light of day; that it would be found impossible to keep the tunnel properly ventilated, and that, in fact, the whole affair was a mistake. How, as a matter of fact, the public *have* "taken" to the line and used it as no line was ever used before, is well known; but it is not known, and never can be known, to how great an extent this has been due to the excellence of the accommodation which Mr. Fowler's judgment led him to provide. In station appointments and passenger accommodation generally the Metropolitan line set an example to the whole of the railways in the kingdom; and the example has, we are glad to say, been appreciated and followed. At the time the Metropolitan line was opened, the carriages employed by all our leading railway companies for metropolitan or local traffic were practically identical with those used on trains running long distances. Yet in the former case, where people are continually entering and leaving the carriages, there is a greater necessity for ample height and space between the seats, and Mr. Fowler, therefore, had constructed for the Metropolitan line—where the stoppages occurred at exceedingly short intervals—carriages with far greater headroom, and, indeed, more spacious generally than any running at that date. It was on the Metropolitan Railway, also, that the public were first indulged with the luxury of thoroughly well-lighted carriages; and it was in fact on this line that the problem of lighting railway carriages by gas was first successfully worked out on anything like an extensive scale. Of course the extra accommodation and the addition of the gas-holders, etc., all involved additional weight

* See V. N.'s Magazine, July page 589.

in the rolling stock; and it is, we think, not to be wondered at that in first designing carriages involving many novel points of construction, this additional weight should have been allowed to become somewhat greater than it need have been.

Leaving generalities however, let us state briefly the accusations against Mr. Fowler's rolling stock contained in the article to which we have referred. As regards the engines, it is affirmed that the driving wheels (the diameter of which is wrongly stated as 5 ft. 6 in. instead of 5 ft. 9 in.) are inexcusably large, and that these large wheels led to the adoption, as a necessity, of large cylinders; our contemporary adding: "We need not stop to explain how great an augmentation of weight this entailed." Further, it is stated that, "It was next assumed that the curves would be bad to get round with a six-wheeled engine, therefore a bogie was introduced principally because the engine was made too long to begin with. This further increased the weight, and so, finally, Mr. Fowler produced the now well-known narrow gauge standard Metropolitan engine, weighing nominally 42 tons, but in all probability at least 45 tons loaded. This monstrous machine is employed to haul trains consisting of five not less monstrous carriages . . . The driving wheels are much too large, the machine too long, and, above and beyond all, the enormous weight of the machine constitutes a grievous defect." Our contemporary then goes on to say that although it has apparently brought grave accusations against Mr. Fowler, yet that these accusations have been made much more forcibly by "no fewer than three of the largest and most powerful railway companies in the kingdom," these being stated to be the Great Northern, the Midland, and the Great Western companies. Moreover, a detailed comparison is made between the Metropolitan and Great Western rolling stock; but this comparison we shall leave for the present, and shall in the first place consider the statements concerning the Metropolitan engines, which we have reprinted above.

To begin with, then, let us consider the assertion—urged so strongly by our contemporary—that the wheels of Mr. Fowler's engines are "much too large." Now of course we cannot say precisely what particular dimension "much" may denote, but judging from the praise bestowed (and much of it most deservedly) on the new Great Western engines, we are inclined to believe that, in this particular instance, the term stands for 9 in., the driving wheels of the new Great Western engines being 5 ft., and those of the Metropolitan engines 5 ft. 9 in. in diameter. It would be foreign to the purpose of the present article to enter into all the arguments that have been advanced for and against large driving wheels, and we shall therefore merely refer to the two principal ones, these being, first, that the larger the driving wheels the less will of course be the number of revolutions made in running a given distance, and the greater, therefore, will be the durability of the tyres and of the wearing surfaces of the "motion" generally; and, secondly, on the other hand, that the larger the driving wheels the greater will be their weight, and the greater also will be the size and weight of the cylinders, pistons, and their connexions, requisite for giving a certain tractive power. Our contemporary, whose remarks we are criticizing, has stated that the "much" too large wheels and cylinders of Mr. Fowler's engines have led to a "great augmentation of weight," but it has deemed it unnecessary to explain how this "great augmentation" is caused. As a fact, the two pairs of coupled wheels of the Metropolitan engines if decreased from 5 ft. 9 in. to 5 ft. in diameter, would be reduced in weight but about 13 cwt.; while the corresponding reduction which might at the same time be made in the size of the cylinders (the tractive power of the engine being maintained the same as at present) would amount to about $1\frac{1}{2}$ cwt., making the "great" total of $14\frac{1}{2}$ cwt. as the saving under these two heads. Of course with the smaller cylinders some reduction might be made in the weight of the pistons, piston rods, connecting and coupling rods, etc.; but this would not amount to much if the bearing surfaces were maintained of such dimensions as to give the same durability as is obtained with the larger wheels. The question then arises whether these little savings in weight would compensate for the more rapid wear of tyres, etc., due to the reduced size of driving wheel; and the only way in which we can answer this question is by referring to the proportions which the locomotive practice of the last few years has shown to be best suited for engines working traffic similar to that on the Metropolitan Railway. In the first place we find that Mr. William Adams, of the North London Line (an engineer who has probably had more experience in working what may be called

"omnibus" traffic than any locomotive superintendent in the kingdom), although he has lately built some engines with 5 ft. 3 in. coupled wheels, has for many years past employed, as his standard locomotives, engines having coupled wheels and cylinders of precisely the same dimensions as Mr. Fowler's; while the Great Northern, the Great Eastern, the London, Chatham, and Dover, and the South-Eastern lines are employing locomotives with 5 ft. 6 in. coupled wheels for their local traffic. A reference to the best practice therefore shows that as regards the size of their driving wheels, there is nothing unusual in the Metropolitan engines, and that there is no foundation for the assertion of our contemporary that these engines have wheels "much too large;" while, moreover, the Midland Company (who are expressly cited by our contemporary in support of its arguments) are running their "metropolitan" trains with engines having driving wheels no less than 6 ft. 2 in. in diameter.

Next, it is stated in our contemporary, that the Metropolitan engines were made too long, and that it was then endeavoured to compensate for this by fitting them with a bogie. If the writer of the article in question had ever designed a locomotive, he would probably never have made so silly an assertion. The fact was, that Mr. Fowler considered—and with good reason—that a locomotive with a flexible wheel-base was best suited for working a line with numerous curves like the Metropolitan, and he, therefore, adopted bogie engines, the result, of course, being that the total wheel-base was rendered longer than it otherwise would have been. In this adoption of a long and flexible wheel-base, Mr. Fowler is also supported by the practice on most of our principal lines, as the following Table, giving the wheel-bases, etc., of engines employed in working metropolitan traffic, will show:

Name of line to which engines belong.	Total wheel-base.	Length of rigid wheel-base.	Arrangement adopted for giving flexibility.
North London	22 2	8 0	W. Adams' bogie.
" "	20 8	8 0	" "
Great Northern	19 3	7 6	W. B. Adams' radial axle-boxes.
South-Eastern	20 6	7 3	W. Adams' bogie.
Metropolitan	20 9	8 10	Bissell's bogie.

The new "Metropolitan" engines of the Great Western Company and those of the Midland Company have certainly rigid wheel bases, the former being 15 ft. 3 in., and the latter no less than 16 ft. 6 in.; but we have yet to learn how the flange wear of the tyres of these locomotives will compare with that of the bogie engines used by other companies; while we must remember that increased flange wear means also increased wear and tear of the permanent way. As for the increased weight due to the adoption of the four-wheeled Bissell bogie on the Metropolitan engines, it probably amounts, we believe, to about 3 tons 2 cwt.; but in return for this there is obtained not only the decreased wear of flanges and rails, but also increased safety. And here we may remark that the statement made by our contemporary, that on the Metropolitan Railway "the bad curves are few in number, and at the worst can do no great harm, because the speed at which they are traversed, as at King's-cross, for example, is low," is far from expressing the state of affairs correctly. All who have ridden over the Metropolitan Railway on an engine well know, or should know, that the line is essentially one with frequent curves; and, although none of these may be considered exceptionably sharp, according to the light in which such matters are now viewed, yet numbers of them are of but 10 chains radius, and are traversed at speeds of over 25 miles per hour.

We now come to the third principal objection made by our contemporary to Mr. Fowler's engines, namely, to their alleged "enormous weight," which it said exercises a most destructive action on the permanent way. Says our contemporary: "There is no denying the fact that the standard engines play havoc even with the permanent way of the Metropolitan Railway, smashing off the tables of steel rails, and grinding out the best Bessemer track, perhaps in the world, as though it were made of iron." Now, notwithstanding the assertions of our contemporary we most emphatically deny that the steel rails on the Metropolitan railway are being crushed or having their tables smashed off by the loads imposed upon them. We lately walked over a considerable length of the line and found no signs whatever of anything but fair and even wear taking place, except at stations where a certain amount of lamination of the rails is caused by the action of the brakes and by the occasional slipping of the engines when starting. There are now in the Metropolitan line, between King's-cross and Farringdon-street, Bessemer steel rails which were laid down in April and May, 1866, and which have consequently been on the road upwards of three years. During that time they have

been traversed by the following numbers of trains:

Metropolitan	161,000
Great Western	39,000
London, Chatham, and Dover	10,000
Great Northern	17,000
	227,000

Even this vast number does not include empty engines passing to and from sheds, and which during the time we have mentioned would probably amount to not less than 15,000 or 20,000. Notwithstanding that they have carried this enormous traffic, the rails show nothing but an exceedingly slight and perfectly uniform wear, and there are no signs whatever of "smashing" due to excessive loads. At the stations the skidded carriage wheels do undoubtedly produce lamination, and it is curious on passing the finger—or still better, the point of a pin or penknife—over the rails to feel how the surface has, as it were, been rubbed down in the direction of the traffic. This, however, has nothing to do with the weight of the engines. Of this weight we shall have more to say when considering the comparison between the Metropolitan and Great Western locomotives; and in the meantime we shall merely remark that the correct weight in working order is 42 tons 3 cwt.—not "at least 45 tons," as stated by our contemporary; while the weight resting on the coupled wheels is 30 tons. These weights are practically the same as those of the standard engines used by Mr. William Adams on the North London line, while the Midland "metropolitan" locomotives, which are stated by our contemporary to be "a modification of Mr. Fowler's design, the engines weighing much less, however," are, in reality, engines with a rigid wheel-base of 15 ft. 6 in., having 16½ in. cylinders, with 22 in. stroke, 6 ft. 2 in. coupled wheels, and weighing, in working order, 43 tons 4 cwt., of which over 32 tons rest upon the coupled wheels.

We shall now consider the comparison made by our contemporary between the standard Metropolitan locomotives and those recently placed on the line by the Great Western Company for working their metropolitan traffic; and in the first place it may be as well that we should give a few particulars of the latter engines, and the work done by them. The new Great Western locomotives, then, have inside cylinders 16 in. in diameter, with 24 in. stroke, and they are carried on six wheels, the driving and trailing wheels, which are 5 ft. in diameter, being coupled, and there being a single pair of leading wheels in front. The wheel base is 15 ft. 3 in., and their weight in working order is a little over 33 tons, of which about 23 tons rest on the coupled wheels. And here, before proceeding further, we may remark that in carrying out our comparison between the Metropolitan and Great Western engines, we are very far from wishing to find fault with the latter. They are of thoroughly good and remarkably neat design, and we believe them to be well adapted for the work which they have to perform; but this work is not the same as that which is required of the Metropolitan engines, and it is in neglecting to note this fact that our contemporary has so greatly erred. The regular load drawn by the Great Western engines over the Metropolitan line between Bishop's-road and Moorgate-street, consists usually of six or sometimes seven carriages, two of these carriages carrying each 40 passengers, including the guard and brakesman, and the remaining carriages accommodating each 32 passengers. The six-carriage trains have thus seat room for 202, and the seven-carriage trains for 240 passengers. Regarding the weight of these carriages we have no precise information; but they are of light construction, and we should think that they probably weigh about 6½ tons each, or about .2 ton per passenger carried. Of the total distance run by the Great Western engines, about five-ninths is run on the Metropolitan line, and the remainder on the Great Western line, where no condensation of the exhaust steam is required. This fact should be taken into consideration in comparing the Great Western and Metropolitan locomotives. The usual load drawn by the latter engines, we should state, consists of a train of five carriages, accommodating 352 passengers, this train being made up as follows: One first class, holding 48 passengers; one composite, carrying 24 first class and 40 second class passengers; one second class, holding 80 passengers; and two third class, accommodating together 160 people. The carriages weigh 16 tons each, their weight being thus .312 ton per passenger for the first class; .25 ton per passenger for the composites; and .2 ton per passenger for the third class.

Arguing on these premises, our contemporary says: "We have, then, the Great Western Company doing the same work that the Metropolitan are doing, with a dead

weight less by at least twenty-five tons per train, if we assume ten of the Great Western carriages, to carry only as many as five of the Metropolitan carriages." Now, as a fact, the ten Great Western carriages could not carry so many passengers as the five carriages forming the usual Metropolitan train, while the saving of weight would, we firmly believe, be under twenty-five tons rather than over it. The assertion that the Great Western Company are doing the same work as the Metropolitan Company with lighter engines and much less dead weight, we must decidedly deny. The maximum train worked by the Great Western Company over the Metropolitan line consists, as we have said, of seven carriages, and taking this as the standard of comparison with the Metropolitan five-carriage train, we find the relative dead weights to be as follows:

	Metropolitan.	G. W. R.
Weight of engine.....	42 tons.	33 tons.
" train, about	80 "	about 45¼ "
Total of engine and train, about	122 "	about 78¼ "
Number of passengers carried.....	352	240
Weight of engine per passenger	.119 ton	.137 ton
Weight of engine and per passenger about.	.346 ton	about .327 ton

We thus see that the weight of the engine per passenger drawn is actually less in the case of the Metropolitan than in the Great Western trains, while the total dead weight per passenger is nearly the same in the two cases. It may be said, and no doubt truly, that the Great Western engines are underwork; but the same is equally true of the Metropolitan locomotives; and, in fact, the latter have been designed for working not merely the present traffic, but the traffic which it is expected will be obtained when the whole line is completed. In fact, the short stations on the line are now being lengthened, to allow of longer trains being worked. Moreover, in comparing the performance of the two sets of engines, it must be borne in mind that while the Great Western trains traverse but 4½ miles of underground line, the Metropolitan trains are worked from Moorgate-street to Westminster, a distance of 9½ miles, and the Metropolitan engines thus require and carry 1,000 gallons of water for condensing purposes against 750 gallons carried by the Great Western engines. The maximum gradient also on that portion of the line traversed by the Great Western trains is 1 in 100, whereas between Praed-street and Westminster there are several gradients of 1 in 70. Thus, the work done by the Metropolitan is much heavier than that performed by the Great Western locomotives.

Taking all things into consideration, we cannot consider that the Metropolitan engines are too heavy for the duty demanded of them. They are certainly 9 tons (not 12 tons, as stated by our contemporary) heavier than the Great Western engines, but they have the advantage of a greater firegrate area, a greater firebox heating surface, a greater water capacity in the boiler (an important matter for engines working underground traffic) a greater adhesion weight, a greater tank capacity, and last, but not least, they have a flexible wheel-base, and are fitted with a compensating beam between the coupled wheels. As regards tractive power, the two sets of engines are practically identical, the tractive force exerted for each pound of effective pressure per square inch on the pistons being 100.5 lbs. in the case of the Metropolitan, and 102.4 lbs. in that of the Great Western locomotives. They would thus possess, as far as cylinder power is concerned, equal capabilities for starting a train; but on an underground line, where the exhaust cannot be discharged into the chimney, the additional firebox capacity and water space in the boiler would give the Metropolitan engines an undoubted advantage for maintaining speed.

Our article has already extended to a greater length than we intended, but we cannot conclude it without directing attention to a most extraordinary conclusion arrived at by our contemporary with regard to the facts we have been considering. It says: "If Mr. Fowler's method of working Metropolitan traffic can be made to pay—and it is—then much more should the Great Western system pay. *In the case of the engines alone, the cost of transmitting each ton of dead weight from place to place cannot be much less than 2d. per ton per mile.* Taking the very moderate estimate of 20,000 miles as the distance run each year by each engine, we have a saving of 12 tons less in the Great Western engines, as compared with the standard Metropolitan engines, of £166 per engine per annum, or for the Metropolitan Railway Company, with 36 engines, a saving of, in round numbers, £6,000 per annum!" The italics are our own, and we fancy that the passage we have italicized will astonish most railway men. As a fact, the locomo-

tive and carriages expenses on the Metropolitan line average about 13d. per train per mile, and taking the mean gross weight of the trains as low as 130 tons, we find the mean cost of transport per ton per mile to be but .1d. instead of 2d. as stated by our contemporary. Extraordinary, however, as is our contemporary's statement that the cost of transport is not less than 2d. per ton per mile, the arithmetic by which this cost is made to show a saving of £166 per engine per annum is still more extraordinary. According to ordinary methods of calculation 12 tons carried 20,000 miles at 2d. per ton per mile would give £2,000 not £166! The real difference of weight of the engines, however, is 9 tons not 12 tons, and at .1d. per ton per mile this gives for 20,000 miles per annum, £75 per engine per annum, or £2,700 for the 36 engines, a sum which we think would be *hardly* compensated for by the decreased efficiency.

IRON AND STEEL NOTES.

SMELTING, CARBURIZING, AND PURIFYING IRON.—Mr. Isham Baggs, of High Holborn, has patented some processes by means of which the smelting, carburization, and purification of iron are greatly facilitated. In charging the furnace, the coal or coke usually thought necessary for smelting is in a great measure dispensed with, and in its place, Mr. Baggs burns in the smelting furnace coal gas, hydrogen, carbonic oxide, or other combustible gas or gases, and also the vapor of petroleum, naphtha, and other hydrocarbons under pressure and in combination with a blast of hot or cold air. In the case of the inflammable hydrocarbon vapors, the same may be forced into the furnace under the pressure of their own atmospheres, or by means of mechanical appliances. The gases and vapors which are employed for the purposes of this invention may be previously mixed with the air furnished by the blast, or may be caused to meet the air in the furnace or at the tuyeres. The proportions of the mixture when a combination of gas or vapor and air is employed are subject to constant regulation by valves. One very convenient mode of obtaining combustible gases for the purposes of this invention is to generate coal gas in the usual way, and then carbonic oxide, and to blow air or carbonic oxide gas under pressure through the retort containing the residual coke.

For the purpose of carburizing the iron, whether in or out of the furnace, as may be desirable, coal gas or other carbides, or other materials containing carbon, are blown through the furnace or brought into contact with the molten metal by blowing them through it. Carbon in any suitable form or combination may also be directly introduced into the furnace for the purpose of carburization, and although generally for smelting purposes it is desirable to exclude all solid mineral fuel from the furnace as part of the charge, yet where a suspension of operations is necessary, such a charge of coal, coke, or other fuel may be introduced into the furnace as will prevent the materials on renewal of work from falling through the crucible or any iron remaining therein or below it from being permanently solidified. When purification is required, hydrofluoric acid is blown through the molten metal on its way from the furnaces, the gases being mixed with common air or with some gaseous diluent.—*Mechanics' Magazine.*

IRON AND STEEL INSTITUTE.—On Wednesday evening, June 23d, at the rooms of the Society of Arts, the first meeting of the newly formed Iron and Steel Institute, which was very fully attended by ironmasters from the North, Lancashire, South Staffordshire, South Wales, Middlesborough, etc., was held under the presidency of his Grace the Duke of Devonshire, the President, who delivered a lengthy and exhaustive inaugural address. His Grace explained the objects of the institute, which are to afford a means of communication between members of the iron and steel trades upon matters bearing upon the respective manufactures, excluding all questions connected with wages and trade regulations, and to arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the manufacture and working of iron and steel. He reviewed the success which had attended the formation of scientific and agricultural societies, and saw no reason why equal advantages should not accrue to the iron trade by association. Then his Grace passed on to review the early history of iron, the manufacture of which was mentioned by Homer and Hesiod, and had been asserted by Mr. Layard to have been known in Assyria in 900 B. C. He then noticed the early methods of manufacture down to the period of the use of coal, which gave such a vast impetus to the manufacture of iron in this country, and afterwards referred to the invention of the "hot blast," the increased supplies of ore, and other causes which had contributed to the present importance of the iron manufacture. The processes by which pig iron, malleable iron and steel are manufactured having been alluded to, the president referred to the utilization of the waste of gases from the blast furnaces, and went on then to show how the raw material and manufacture were distributed over the world. The problems to be solved now, which were of the most importance, were economy in the consumption of fuel, and a greater ultilization of the waste gases. Mineral oil had been used in the dockyards in place of coal. It was also highly important to obtain the metal as pure as possible, and though chemistry had been brought to the aid of the manufacture, yet the chemistry of iron and steel was still in many respects obscure and uncertain. His Grace concluded by a brief bu teloquent reference to the importance of iron as an essential necessary of civilized life. Mr. Richard Fothergill, M. P., moved a vote of thanks to his Grace for his address, and requested that it should be printed. Mr. Isaac L. Bell seconded the resolution, which was carried by acclamation.—*Engineering.*

METAL PRODUCT OF RUSSIA.—In Russia, in 1867, there were 1,211 iron smelting works, employing 87,086 hands, and yielding products valued at $92,042,918. The value of the manufactures of other metals is thus stated:—Silver, $2,205,164; lead, $3,791,840; copper, $2,991,552; brass, $1,608,271; zinc, in bars or plates, $6,385,993; other zinc, $2,104,254.

PARTICULARS OF BLAST FURNACES.

Prepared by Dr. Thomas Egleston, jr., Professor of Mineralogy and Metallurgy, Columbia College School of Mines.

NOTE.—The dimensions are in meters = 39.38 in.

American Furnaces (Charcoal).

NAME OF THE STATE.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Connecticut	7.315 to 10.055	3.048 to 5.18	1.52 to 1.828	.533 to .609	3.914 to 1.22	2.13 to 2.74	.609 to .710	.444 to .723	2.076 to 9.144	8.186 to 16.386	10.985 to 25.974
Indiana	8.534	3.048	1.828	.508	.914	3.048	.914	1.198	4.121	18.528	23.847
Kentucky	10.972	2.743	.914	.....	.863	2.743					
Michigan	12.192 to 12.801	3.960	.456 to 1.828	.609 to 634	1.066 to 1.524	2.743 to 2.895	.939 to 1.117	.446 to 1.304	6.537 to 10.851	26.805 to 33.152	36.033 to 41.100
Missouri	12 192 to 13.716	1.524 to 3.149	1.778 to 1.828	.701	1.026 to 1.524	2.895 to 3.352	.713 to .914	.709 to 1.198	3.979 to 5.276	35.774 to 42.660	40.462 to 49 134
Maryland	8.229 to 10.363	1.244 to 2.631	.152 to 1.828	.508 to .584	.558 to .751	2.285 to 5.539	.558 to .762	.044 to .832	1.502 to 21.057	10.318 to 48.999	12.652 to 70
New York	9.75 to 13.106	2.895 to 3.656	1.524 to 1.980	.406 to .660	.50 to 1.219	2.438 to 3.352	.609 to 1.676	.583 to 1.298	3.623 to 4.257	33.537 to 41.338	38.377 to 46.259
Pennsylvania	8.534 to 10 058	2.438 to 3.048	1.371 to 1.524	.355 to .609	.406 to .812	2.590	.193 to .609	.039 to .427	1.384 to 2.564	10.594 to 16.057	11.948 to 18.478
South Carolina	12.192	1.524	1.219 to 1.524	.....	.914	2.743	.584	.368	3.744	26.439	30.559
Tennessee	12.192	3.566	1.828	584	1.219	2.133	.761	.831	3.228	19.290	23.341
Virginia	10.058 to 12.192	4.926	1.828 to 2.438	.....	.558 to .914	2.743	.609	.708	4.573	22.541	27.822

NAME OF THE STATE.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent.		
Connecticut	4.064 to 10.106	2.580 to 2.878	1.9 to 3.6	1 to 4	.050 to .092	cold to hot	.315 to 2.268	Brown Hematite	40-45	White Gray Mottled	130-200 bushels
Indiana	7.112	3.353	2.3	1	.076	hot	.....	Hematite	40	Soft gray	185 bush.
Kentucky	6.096	.....	2.2	.....	.....	cold	.....	Various pipe kidney	40-75	Gray	200 bush.
Michigan	14.224 to 16.256	2.500 to 2.533	5 to 5.5	2	.088 to .101	230° to 314°	.624 to .676	Hematite Magnetite Specular	59-65	Gray White Mottled	105-155 bushels
Missouri	15.240	2.906 to 3.224	4.5 to 4.7	2 to 3	.076 to .095	314°	1.132 to 1.585	Specular	54.65	Gray	133-160 bushels
Maryland	5.080 to 7.112	2.075 to 9.856	1.2 to 2.6	2	.063 to .288	314°	.....	Baltimore ore and Hematite	40-45	Gray White Mottled	130-170 bushels 100-192.1
New York	5.080 to 10.160	5.443 to 6.295	2 to 3	1 to 6	.046 to .068	300° to 800°	.113 to .453	Hematite Magnetite	36-54	Gray White Mottled.	bushels
Pennsylvania	3.551 to 6 096	2.657 to 4.041	1.6 to 2.3	1 to 2	.063 to .298	cold to 148°	.339 to .907	Brown Hematite	33-40	Gray	150-220 bushels
South Carolina	2.032	15.034	.7	2	.076	cold	9k.	Magnetite Hematite	40-50	Gray Mottled White	350-400 bush.
Tennessee	5.080 to 7.112	3.830	2.8	1	.088 to .127	cold	.....	Limonite	45-50	Gray Mottled	250 bush.
Virginia	3 048 to 6.096	4.563	.9 to 2.2	1	.076	cold	.....	Red Hematite	50-80	Gray White	200 bush.

American Furnaces (coke and coal mixed).

NAME OF THE STATE.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Pennsylvania	13.715	2.895	1.524	1.971	1.828	3.960	1.752	3.670	9.215	69.862	82.747

American Furnaces (coke and coal mixed)—Continued.

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent.		
Pennsylvania ..	20.320 to 36.587	2.908	7.1	7	.076	314° to 370°	.793k.	Magnetite Specular	50-65	all kinds	80 bushels.

American Furnaces (Bituminous Coal).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Ohio	12.801 to 18.288	4.112 to 5.186	.761 to 1.828	.914 to .964	.869 to 2.855	3.656 to 4.876	1.524 to 2.133	1.678 to 3.333	13.510 to 43.329	50.486 to 156.263	77.999 to 202.825
Pennsylvania	12.18 to 12.29	4.112 to 5.485	1.217 to 1.828	.609 to .659	1.524 to 2.439	3.540 to 3.960	1.825 to 1.980	5.627 to 10.320	16.402 to 21.413	58.651 to 89.189	74 to 111.218

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent		k.
Ohio	20.320 to 40.640	3.124 to 4.980	4.7 to 8.3	6 to 7	.088 to .127	425° to 536°	1.019 to 2.721	Black band Lake Superior	35-65	White Gray Mottled	2500-4025
Pennsylvania ..	14.224 to 20.320	5 to 5.743	3.9 to 5.1	3 to 6	.063 to .076	314°	1.585 to 2.268	Lake Superior	35-36	Mottled	2258

American Furnaces (Anthracite).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
New York.....	12.801 to 18.29	3.048 to 7.315	1.676 to 2.133	.761	1.828 to 2.743	3.60 to 6.705	1.21 to 1.828	2.624	10.350	126.282	3.294 to 228.937
New Jersey	11.582 to 19.812	2.895	.711	.....	1.219	2.895 to 6.096	1.372	1.050	8.095	30.279	39.442
Pennsylvania.	9.144 to 17.373	2.743 to 9.142	.609 to 2.439	.....	1.066 to 3.658	2.3 to 6.705	.736 to 2.438	.599 to 5.625	4.012 to 50.666	24.619 to 134.539	29.273 to 234

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent		
New York.....	14.228 to 37.593	4.402 to 8.658	2.9 to 8	2 to 6	.076 to .116	cold to 425°	1.132 to 2.721	Magnetite Limonite	40-68	Gray White. Mottled	2
New Jersey....	8.279 to 24.384	4.764	2.86 to 4	3 to 5	.046 to .101	259° to 303°	1.360 to 1.814	Magnetite Limonite	.....	.....	8.581k.
Pennsylvania ..	9.144 to 35.561	3.029 to 10.875	2 7 to 7.9	3 to 12	.036 to .177	148° to 481°	1.132 to 3.628	Magnetite Hematite	30-60	Gray White Mottled	1500-2000

American Furnaces (Coke).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyere.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etal-lages.	Volume of shaft.	Total volume.
Pennsylvania	12.192 to 14.325	1.904 to 3.352	.914 to 1.524	.609 to 1.219	.914 to 2.438	3.048 to 3.960	.609 to 1.524	.442 to 1.666	1.142 to 12.813	34.827 to 89.830	36.411 to 104.39

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent		
Pennsylvania	7.620 to 26.416	3.989 to 4.788	2.5 to 6.6	3 to 4	.076	342°	1.132 to 1.585	Lake Superior	33-62	Gray	100 bush.

Foreign Furnaces (Charcoal.)

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etal-lages.	Volume of shaft.	Total volume.
Nova Scotia	9.753	3.048	1.524	.533	1.015	2.743	.914	.999	4.322	29.898	25.279
Austria	8.72 to 13.97	1.58 to 4.424	.47 to 1.90	.527 to .632	.553 to 1.58	1.869 to 3.44	.67 to 1.896	.446	4.692	15.188	13 to 61.15
France	8 to 10.70	2.33 to 5	.95 to 2	.54	.60 to 1.45	1.90 to 2.75	.52 to .80	.364 to .530	2.236 to 5.059	66.993 to 14.716	11.407 to 18.960
Prussia	7.85 to 11.93	2.67 to 2.90	.42 to 1.65	.....	.86 to 1.26	2.22 to 3.14	.44 to .79	.....	.....	.....	18.33 to 30.8
Russia	6.90 to 15.70	4.84 to 6.84	.50	.....	2.16 to 2.44	3.63 to 3.95	.63	.207 to .720	18.580 to 31.556	5.879 to 66.544	60.2 to 98.155
Sweden and Norway	9.75 to 12.42	3.28 to 4.70	.19 to 1.50	.42 to .61	.88 to 1.62	2 07 to 2.54	.74 to 1.25	.120 to 1.542	4.089 to 8.992	16.471 to 96.018	20.842 to 34.331
Tuscany	9 to 10.60	3.40 to 4.75	.70 to .80	.....	.90 to 1.85	2.10 to 2.50	.80 to 1	.402 to .549	1.856 to 10.333	7.281 to 22.857	9.539 to 33.739

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent		
Nova Scotia	7.112	3.554	2.5	2	.092	92°	.340 to .453	Limonite	48	Gray White Mottled	100 bush.
Austria	2.31 to 23	2.352 to 5.667	.....	2 to 5	.02 to .06	cold to 2.25°	.018 to .79				
France	2.5 to 4	3.908 to 4 125	1 to 3	.07 to .53	.....	cold to 2.50°	.04 to .14	.....	28-43		
Prussia	.....	.....	3								
Russia	22.800 to 29.352	2.155 to 2.947	2 to 12	.....	.....	.....	.....	Magnetite	67-68		
Tuscany	.....	.....	1-3								

Foreign Furnaces (Coke.)

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. of tuyere.	Volume of hearth.	Volume of etal-lages.	Volume of shaft.	Total volume.
Belgium	13.26 to 18	3.50 to 5.85	2.10 to 2.87	.....	2.60 to 3.80	4.12 to 5	.914 to 1.70	1.814 to 6.468	9.662 to 28.574	71.220 to 214.210	88.843 to 227.340
France	13.90 to 16	4.90 to 6.25	.85 to 2.45	.70	2 to 3	3.96 to 5	.84 to 1.80	1.218 to 5.089	17.337 to 34.111	61.695 to 134.076	80.250 to 173.876
Prussia	10.68 to 15.70	2.714 to 5.97	.659 to 2.07	.....	1.897 to 2.83	3.45 to 4.71	.639 to 1.593	.211 to 2.537	9.230 to 29.855	70.364 to 101.936	78.805 to 166

Foreign Furnaces (Coke)—Continued.

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent		
Belgium.....	32	3.5	2	.08	.....	.....	.12	Limonite	35-40		
	to	to	to	to			to	Hematite			
	40	5.8	3	.14			.17				
France.....	15	2.996	2	.06	.....	250°	.12				
	to	to	to	to		to	to				
	40	9.326	5	.09		350°	.25				
Prussia.....	7	3.266	3	.06	.....	270°	.16				
	to	to		to		to	to				
	30	7.233		07		300°	.88				

Precautions in Building Furnaces.—In the last two years some accidents have occurred during the erection of furnaces. We have examined the causes in several of these cases and have found that they have been attributable to the following defects and oversights :

1. *Insecure foundations.* Some engineers are not practically aware of the exceeding pressure and weight arising from the methods of construction in furnaces and in the hoists. Some of these structures, from the conditions under which they have been erected, require a small area of base with comparatively enormous superincumbent weight. Perhaps we might have made no distinction between pressure and weight, but we think it necessary to make what we apprehend is a true distinction in this case. By weight is meant that force of gravity applied at the juncture where the generally-considered homogeneousness of material terminates, and by pressure, the same force as applied in the general structure or material itself. Allowing this definition, we would say that the weight of some furnaces of moderate size creates a formidable amount of pressure upon foundations. Is it not therefore strange, that with the addition of material of the charges, cracks and injuries occur after, if not before the blowing in? We have seen some furnace and hoist-walls give way before they were quite complete. For illustration sake, let us suppose we weigh a furnace of 50 ft. high and 12 ft. bosh, builded of limestone, and put up in the usual way. As the stack will be filled with material whose average density will fully equal that of limestone, or other rock used for this purpose, we may consider its specific gravity 2.7, water being 1. Taking the latter at 60 lbs. per cubic foot, we shall have fair data to begin with. Supposing the above furnace to be only 20 ft. square, on the average, to level of tunnel head, and the weight of each cubic foot to be 162 lbs., we shall have a reasonable average weight. These elements would give a weight of 1,446 tons, and the soil (if builded upon soil), would receive, if all things were uniform, a pressure of about 56 lbs. upon the square inch. It will therefore readily be seen how easily a hoist, or furnace stack, may be injured by the yielding of even a part of the foundation, causing, as we have seen in more than one instance, a crooked wall before any fire was kindled within the works. We were informed by a gentleman who had more than fifty years of experience in building, that small stones laid in the trench excavated for walls, were more secure as a first layer than large stones, and we were referred to a large and heavy stone structure, erected more than twenty years before, in which heavy machinery had been running since its erection, and not a crack of any kind was apparent. We saw the walls of this building after they had been subjected to a very severe fire, but no crack made its appearance, giving additional evidence that there was no weakness in the foundations. There is much practical philosophy, unusual as it may seem, in the laying small stones down first and letting them run into the ground conformably to the under surface of the large foundation stones used in furnace constructions and their accompanying walls and hoists.

2. *Improper building material.* We have seen only one illustration of unwise economy in this respect so far as furnace works are concerned. In this case the stack and hoists became useless after being nearly completed, because of the use of a friable sandstone, taken from near at hand to save hauling from a distance. The pressure was too great for the stone. Materials are improper when the individual stones are small, especially at the corners of the structure, and they should decrease in ascending, as a matter of preference, however, and not of necessity. It is a mistake to suppose that all limestones are unfit for furnaces. Some silicious stones of that nature answer admirably when protected from fire. The conglomerates, consisting of quartz pebbles cemented with sand and aluminous silicates, form an excellent material where the adhesiveness is sufficiently great. The conglomerates of the anthracite and other regions form excellent hearthstones, and have been used most efficiently for many years, as some sandstones have been also. The composing pebbles vary from large stones to smallest pebbles, and there is no difficulty in obtaining large masses. In some places fire clay bricks, of large size, have been used for hearthstones with satisfactory results.

Kaolin mortar, containing soda and lime, we have good reason to suspect, is inferior. The same may be said of the fire bricks made from such material. Good kaolin mortar is generally fine in texture, with little grit, and generally hardens soon, and when dry, the mortar will not rub off in gritty particles. In putting up several furnaces we had a fair trial made of kaolin clays, or fire clay cement, and have found, thus far, that the clays containing no lime or soda and partaking of the nature of silicate of alumina only, appeared to set more firmly as a mortar and remain uninjured longer as bricks. The lime-kaolins are affected comparatively more rapidly than any other. Nothing but analysis can detect it, although we have seen some powdery kaolins which were lime-kaolins, and we have suspected that this peculiarity might owe its origin to the

presence of lime or soda. But when properly mixed and subjected to strong heat in a smith's fire, then kaolins are easily tested. The above are the chief causes of defects in furnace building.—*American Exchange and Review.*

BLAST-FURNACE ENGINES AT THE LILLESHALL COMPANY'S WORKS.—The beams are of the horsehead class, and are 30 ft. from center to center of cylinders, and they are cast of the Lilleshall Company's cold blast iron. Each beam is composed of two flitches about 8 in. apart, the thickness of the bosses for the main centers being 9 in. The beams are supported midway between the cylinders upon an entablature 3 ft. deep resting upon four massive columns, mean diameter 17¼ in. The columns and entablature, as also the nozzles, are elaborately decorated in the Doric order. The spring beams, which are of pine, 20 in. by 12 in., pass through cast iron saddles upon the entablature, and rest upon the walls of the house. The beams are 4 ft. 8 in. deep at the center. The main centers are 21 ft. 6 in. above the floor of the house. They have journals 18 in. long and 10 in. diameter, and the pummer blocks are fixed on saddles upon the entablature, and are each held down by five bolts, one bolt 3 in. diameter passing down right through the column into the foundation. The main links are 4 ft. 3 in. long between end centers, with bearings 6 in. long and 4½ in. diameter, and the radius links are connected to studs carried by brackets fixed to the spring beams.

The steam cylinders are 40 in. diameter, with a stroke of 8 ft. 6 in. They are clothed with felt and mahogany lagging, and have an ornamental packing stage round them. The piston rods are of Bessemer steel, 4¾ in. diameter, and the pistons are fitted with metallic packing. The valves are of gun-metal, of the double-beat class 10 in. diameter, and are worked by cams keyed upon a horizontal shaft below the floor, which is set in motion from the crank shaft, through the intervention of a lay shaft and bevel gearing. The steam is cut off at quarter stroke. The air pumps are 29 in. diameter and 4 ft. 3 in. stroke, and are worked by rods attached to the beams midway between the center of the cylinders and main centers. The condensers are 29 in. diameter and 5 ft. 9 in. high, the eduction pipes being led into the top. To the other end of each beam, at a distance of 4 ft. from the main center, are attached three rods bracketed together, which work respectively two 6 in. feed pumps and one 14 in. cold water pump. The connecting rods are of massive oak between two wrought iron straps 5 in. by 1¼ in., with ⅞ in. bolts through, and fitted at each end with cast blocks, brasses, gibs, and screw cottars. They are 27 ft. 5 in. between end centers, and are coupled to the beams at a point 13 ft. 4 in. distant in a straight line from the main center. The lower ends are coupled to cast iron cranks 5 ft. 2 in. throw, the crank pins being of hammered iron, with journals 6¼ in. long and 5 in. diameter. The fly-wheel is 20 ft. diameter and nineteen tons weight; the rim, which is 8 in. by 18 in., is casted in one piece. The arms, eight in number, are blocked and keyed into the rim, and the other ends are turned to fit holes in the center boss to receive them. The center is bored and keyed on the shaft. The fly-shaft has journals 18 in. long and 13 in. diameter. The seat of the wheel is 14 in. diameter. The blowing cylinders are 86 in. diameter, and same stroke as the steam cylinders, viz: 8 ft. 6 in. Inlet valves are placed in boxes on the cylinder covers and on grids in the cylinder bases, and their combined area at one end of the cylinder is 5¼ square feet. Outlet valves are placed in wrought iron boxes at top and bottom of cylinders. Their area at one end is 1.33 square feet. These valves are made of two thicknesses of leather sewn together; and as all the inlet and outlet openings are grated, no plates or weights are required, and the valves answer the piston readily, the result being a superior blast. The piston rods are of Bessemer steel 6 in. diameter. The pistons are packed with cotton gasket —which when set hard and lubricated with black lead is found to work satisfactorily—and are cast with loose segments for convenience of packing. The blast is supplied cold to five furnaces at a pressure of 3¼ lbs. per square inch, the engines running seventeen strokes per minute, with a steam pressure of 35 lbs. The blast is delivered from cylinders into wrought boxes at top and bottom of cylinders, connected by a 3 ft. wrought iron pipe, and thence through a conical pipe to the 5 ft. main, which supplies the tuyeres. There is a large opening in the engine-house in the rear of the blowing cylinders louvre-boarded to admit the air to the inlet valves. The cylinders are all firmly bedded upon stone foundations, and are each held down by four 2¼ in. bolts passing down 15 ft. below the floor.

The engine-house is 58 ft. long, 25 ft. wide, and is built of stone and brick, the walls being 3 ft. thick. The engines are supplied with steam by five Cornish boilers 31 ft. long 7 ft. 7 in. diameter, each with two 3 ft. flues through, and are fired entirely by the waste gases from one furnace.—"*The Engineer.*"

ECONOMIZING FUEL IN BLAST-FURNACES.—After standing for more than six months for alterations, and the putting down of new machinery, the Wingerworth Furnaces, near Chesterfield, are once more at work. Their appearance, however, is very different to what it was before the improvements to which we are about to allude took place. The old furnaces gave out the usual smoke and flame from the top, but at present, on passing, it is difficult to say whether they are in blast or not, so free are they from the usual indications one looks for. This result has been attained by taking the gas from the top, and utilizing it in a simple yet efficient manner. To effect this object, new boilers, heating-ovens, and gas apparatus, have been put down at considerable expense. The gas is conducted by a pipe to the bottom of the furnace, from whence it is sent into the boilers and heating-stoves, and there consumed instead of coal. The blast of the furnace is heated to a temperature of from 900° to 1000°, without the use of any coal whatever. The gas is taken from the top of the furnace by a process similar in many respects to that adopted at some of the works in the North of England, but somewhat different as to the mode of conducting off the gases. The alterations have given the most satisfactory results, the produce of iron from the same quantity of ore being considerably larger than by the old method, whilst the quality is also superior. The saving in fuel—an item of so much importance—has been something enormous, making a difference of many tons of coal per week, yet doing the work more efficiently. The alterations and improvements were suggested by Mr. Gjers, of

Middlesborough, and ably carried out by Mr. Marsh. The boilers, which are arranged for being worked by gas were made by the Parkgate Company. The cost of the alterations, which is considerable, will soon be repaid by the great saving in fuel, and the superior quality of the iron produced. From the many advantages of the system we think it is worthy of the consideration of iron makers in all parts of the kingdom—more especially in those districts where coal and coke have to be imported from a distance.—*Mining Journal.*

RAILWAY NOTES.

THE RAILWAYS OF INDIA.—A great deal has been said and written respecting the completion of the Pacific Railway across the American continent, and much praise has been very justly bestowed upon the energy of the American character which has brought the work to its present position. While, however, we are lavish in our expressions of admiration for the great qualities which have thus been called into existence, we ought not to lose sight of the still greater works which have been accomplished in India, in the matter of railways. A vast work has been carried on silently and unobtrusively, and under difficulties even greater than any which have been experienced in regard to the Pacific Railroad, and we claim for those by whom these great works have been achieved some share of that admiration which is given so freely and so fairly to our American cousins.

The Pacific line, including as it does the two separate schemes of the Union Pacific and the Central Pacific, is about 1,700 miles in length. Two of our leading Indian lines, viz: the East Indian and the Great Indian Peninsula, at present in work, have a joint mileage of 2,230 miles, and when completed it will be 2,768 miles, greater by more than one-half of the whole length of the Pacific road. Like the Pacific, these lines cross our Indian empire from east to west, and connect Bombay and Calcutta, just as the Pacific forms the connecting link between San Francisco and New York. By means of the East Indian a railway connects Calcutta with Delhi, more than 1,000 miles distant from each other; in the south, Madras and Baypore are connected by a line crossing Southern India; Nagpore, in Central India, is connected with the port of Bombay; by means of the flotilla and Punjaub line, Lahore in the northwest, and Kurrachee in the Indus are brought into direct connection with each other. There are now actually completed and at work in India, 3,942 miles of railway, or about 600 more than the whole mileage between New York and San Francisco, and there remain to be completed of lines already sanctioned 1,665 miles. This great extent of railway has been constructed in a country many thousands of miles distant from England, where, with a trifling exception, the whole of the capital was provided. For the construction of these works there was required to be shipped from this country 3,529,000 tons of goods, of the value of £23,252,000, and which was conveyed in 5,339 ships. In America no such difficulty as this was experienced. The road, as it was formed, was enabled to carry the iron and timber required for the construction. The contractors worked from an already organized base of railways at home; the materials for the Indian lines had to be borne over thousands of miles of a sea voyage.

In both cases the Government of the country gave valuable aid to the great works. The United States Government issued their 6 per cent bonds at the rate of about £3,000 for each mile completed. In India, the Government gave its 5 per cent guarantee on the capital required. The Government of India has already paid as interest on the capital subscribed a total of £22,212,000. The amount of pecuniary assistance given by the United States Government, although large, must have been considerably less than that paid by the Indian Government, the whole amount of bonds issued not greatly exceeding £5,000,000 sterling. Of the amount paid by the Government of India in the shape of guaranteed interest, £9,500,000 has been already repaid out of the earnings of the railways over and above the guaranteed interest. The balance is to be repaid out of the half surplus profits over 5 per cent, and, judging from the results already obtained, a few years will suffice to clear off this amount of indebtedness. The position of the United States Government is by no means so favorable, as it appears that the amount of the Government bonds has been overlaid by the bonds of the company, which take precedence of the Government advances.

The construction of the Indian railways has presented difficulties of a much more formidable character than those which have been met with on the Pacific line. It is true that this railway has been carried over vast plains and mountain ranges of which little was known, and in the face of the attacks of hostile Indian tribes. In India, the works were carried out in the face of difficulties connected with the oppressive heat of the climate—through forests and jungles which were the resort of savage animals, and the people employed were natives of the country, speaking a language unknown to those by whom they were employed, and whose habits and modes of life unfitted them for labor such as that on which they were engaged. Great works such as those of the Bhore Ghaut and Thull Ghaut inclines presented difficulties equal to, if not greater, than any experienced in the crossing over the Rocky Mountains. Streams wider and more rapid than met with between Omaha and San Francisco have been successfully bridged, and present some of the greatest triumphs of modern engineering science.

While congratulating ourselves upon the results attained, so far as they affect the national character, it is not less a source of satisfaction to see how great has been the benefit already derived from railways in India. Ten years since the time occupied in traveling from Calcutta to Silma was four weeks—it took four months to march a regiment between those places; the distance is now traversed by a railway in five days. Last year 13,746,000 passengers traveled upon the Indian railways. It is worthy of notice that of this number not less than 13,074,000, or within about 700,000 of the whole number conveyed, were third class passengers. The total sum paid by railway travelers was £1,376,000. The goods traffic upon the whole of the railways yielded £3,320,000 of gross revenue. Those scruples of religion and distinctions of caste which have been for so many ages the bane of Indian society are fast disappearing before that mighty leveler of the age—the locomotive. Separate carriages or compartments were in the first instance provided for women, in deference to the feeling of dislike universally entertained at wives or daughters being seen by strangers; separate accommodation for different

castes was also provided. Now all is changed, or rapidly undergoing a change. Brahmins, too, of the purest blood, travel in the third-class carriage, huddled in crowds with the most wretched Pariah, whose very presence near the household roof would in former times be regarded as the most deadly pollution. Railways, too, have been of immense service in encouraging the cultivation of cotton and other produce, in the working of iron and coal mines, by the facilities which they have afforded for bringing the produce to good markets and convenient ports for shipment. The merchant is enabled by means of the railway to deal directly with the cultivator of cotton and grain, and by this means increases the profits on their mutual transactions.

For the carrying on of the traffic upon the 3,942 miles of railway in India, there are now 937 locomotives, 2,733 passenger carriages, and 18,226 trucks and wagons, making a total of 20,959 vehicles. From the able report of Mr. Juland Danvers, we learn that there are employed on the railways of India not less than 39,099 persons, of whom 36,048 are natives.

The entire capital of £75,000,000 has been provided by 58,346 proprietors of stock and debentures, giving an average holding of about £1,300 each, and affording to them an investment scarcely less secure and much more remunerative than British Government stock. The capital estimated to be required for completing the railway system so far as it is at present sanctioned is £93,916,000. Of this sum authority has been given to raise £84,386,000, and the amount actually raised to the close of the last financial year was £76,579,000.—*Railway News.*

Railroad Frogs.—There is no portion of the permanent way of a railroad subjected to harder usage than that part of it where frogs are placed, for the purpose of effecting a crossing from one track to another. At these points the wear and tear is always more than double that of the ordinary track, and the existence of a frog has, at the best, been a precarious one, and often times but very short lived. From the primitive frog made from wrought or cast iron, we advanced to frogs with cast-iron bed plates plated with steel, riveted or bolted on, while others were of wrought-iron with movable wing rails and steel points. Then there were frogs made entirely of cast cast-steel and so arranged that when the top face of the frog was worn, it could by being simply overturned be made to live as it were, a double life. Each frog has in its generation been considered more economical than its predecessor, yet, even those of cast cast-steel—probably offering greater advantages than others preceding them—have the same objection as all cast frogs and are liable to crush under heavy weights, or break with concussion or when subjected to the effects of the severe winters of this country.

A hammered steel frog lately patented in America by Messrs. Armstrong & Co., Steel and Iron Works, Rotherham, Yorkshire, and 43 Exchange Place, N. Y., appears to possess advantages in strength and durability that other frogs do not have, and the testimony of many of the leading engineers in Europe, where the frog has been in use for three years without showing the slightest wear, leads to the believe that it is the best frog yet introduced.

The frog, as has been stated, is made from hammered crucible cast-steel, drawn from the ingot without a weld. It is reversible; is finished in the planing machine and is perfectly true to the required angle. It will neither crush nor break under heavy weights, nor with trains running at great speed. Its reliability is not decreased when subjected to severe frosts, and being of hammered metal, its elasticity prevents the rigidity felt in running over all cast crossings. When the frog has fulfilled its first purpose, the metal being necessarily a good mild steel, to bear hammering and planing, it can be sold for a large proportion of the first cost or can be converted into forgings or rolled into sheets. From a monetary point of view, this frog is more economical than the ordinary steel frog cast in moulds and, apart from this consideration, its durability is probably more than double and the reliability much increased. These frogs are also made non-reversible, an arrangement which materially reduces their first cost without decreasing their other advantages.

Messrs. Armstrong & Co. have also patented a frog composed of a cast iron bed plate with a working face of cast cast-steel. This steel facing is not riveted or bolted on, but in the process of manufacture, the two metals are incorporated, and the frog is complete in one casting. In practice it has been found, that frogs thus made are much sounder than the ordinary cast cast-iron frog and are insured perfectly free from blow-holes. They possess the recommendation of being low priced and durable. C.

Railroad *vs.* Railway.—A correspondent offers the following considerations: The use of rail*way* for rail*road* is improper—the English speaking public to the contrary, notwithstanding. The question lies in the appropriateness of *way* or *road*. The following passage from Crabbe's Synonyms, a book of the best authority, will help us in our determination.

"*Road* comes no doubt from *ride*, signifying the place where one rides. *Way* is the generic term; it is the path which a person chooses at pleasure for himself.

'He stood in the gate, and asked of every one
Which *way* she took, and whither she was gone.'
Dryden.

The *road* is the regular and beaten *way*."

Let me also quote from Gray's Synonyms, page 52: "Way is the general term, and road is the species of way. Instead of keeping the high-road to a town, you may frequently go a shorter way across the fields."

When we Americans coin a term that is correct, we should not give it up and use another because it comes from England.

Color Blindness and Railway Disasters.—One cause of railroad accidents has been discovered in England. It is what is known as color blindness. An engineer ran his train into another, causing great damage. On investigation it was found that he could not distinguish red from green, and had mistaken the signal lights.—*Exchange.*

We have an excellent way of avoiding such disasters in America—not having any signals at all.—*Ed.*

Bridges on the Pacific Railway.—Over 50 new bridges to replace temporary bridges on the Union Pacific Railroad have been built at Chicago and shipped and put up this season, and new ones will be completed over the whole line in 60 days.

RAILWAY CONSOLIDATION.—Consolidation, which for a few years past has been the leading feature in railway strategy, is now operative upon the grandest scale. The Pacific route has given a fresh impetus to the plans by which "through business" can be facilitated and opposition set aside.

The recent combination of the roads between Boston and Albany under one direction, the plan now maturing for uniting all the lines, finished or unfinished, from Boston to Oswego, the union of the Lake Shore and the Cleveland and Toledo companies, the successive purchases and consolidations of stock by which the Chicago and Northwestern, and the Milwaukee and St. Paul railroad companies have grown to their present importance, are all examples of the rapidity with which the idea is gaining ground. These consolidations have practically enabled two great companies to control all transportation on the great middle link, *i. e.*, between Chicago and Omaha.

It is further proposed to unite in one company and under one management a continuous line of railway from New York to Omaha. This proposed corporation is to hold and administer the property and franchises now held by the Hudson River, the New York Central, the Buffalo and Erie, the Lake Shore and Cleveland and Toledo, the Michigan Southern, and the Chicago and Northwestern Railroads, including 2,480 miles of completed and equipped railway. The gross income of these companies for last year was $44,820,893.

The Pennsylvania Railroad Company leases the road of the Pittsbugh, Fort Wayne, and Chicago Railway, with all its branches, for 999 years, commencing July 1, 1869. By the terms of the lease, the former company agrees to pay the interest on the debt of the latter, and in addition thereto the sum of $1,380,000 per annum as rent for the property. The capital of the Fort Wayne Company is $11,500 000; consequently the sum of $1,380,000, named as the annual rent, is 12 per cent on the capital. The directors of the P., F. W. & C. propose to increase the amount of their stock, making the annual rent 7 per cent on the capital as increased. The P., F. W. & C. is itself a consolidation of three original companies, whose lines conjointly connected Pittsburgh and Chicago. It became involved in debt, and in 1861 was sold under foreclosure, the present company becoming the purchasers in 1862. This is but one step in the purpose of the Pennsylvania Railroad Company, but all reports as to other consolidations have no authority.—*American Exchange and Review.*

TURKISH RAILWAYS.—In view of the great expansion of commerce which the Suez canal and the Turkish railways will create in the empire, it is proposed, among other works of magnitude, to make spacious harbors for the chief seaports, such as Constantinople—which is totally without accommodation of this kind—Salonica, etc. As regards Turkish railways, the nearest connecting point with Austria will now be Sissek, and not Brod, as formerly. Here the junction with the Southern line will be effected, and by this means the route to Trieste and Fiume, as also to Vienna and South Germany, *viâ* Northern Italy, to Southern France, will be accomplished. In the other direction the State Railway from Gross Kikinda to Belgrade will be constructed, and thence be connected with the Servian Railway.

TESTS OF STEEL AND IRON CAR WHEELS.—We have been furnished with the minutes of some tests made upon a cast steel car wheel, Tarr's patent, made at the "Black Diamond Steel Works," at Pittsburgh, Pa., and tested at the shops of the Pennsylvania Railway at Altoona, June 26, 1869. The test was that of the drop, weighing 1,200 lbs., falling upon the wheel, placed on bearings two feet apart, the blow on the hub:

1st blow, 9 feet fall, no apparent injury.
2d " 11 " " " " "
3d " 14¼ " " " " "
4th " 16 " " " " "
5th " 20 " " " " "
6th " 28 " " " " "
7th " 28 " " cracked at hub.
8th " 28 " " drove hub through the plate of the wheel, leaving the whole tread and guard around the circumference of the wheel perfectly sound. The steel wheel weighed 444 lbs.

At the same time and place the following tests of the best iron wheels in use were made:

Ramapo, 1st blow, 10 feet, broke in many pieces.
Lobdell, 1st " 7 " " " " "
" 2d " 10 " " " " "
German, 1st " 7 " " " " "
Whitney, 1st " 5 " " " " "
" 2d " 7 " " " " "
Whitney, 1st " 7 " " " " "

The cast cast iron wheels weighed 550 lbs. each. These tests are rather crude in character, but they establish the fact, pretty well known before, of the superiority of cast steel over cast iron, in resisting the effect of hard blows. A well made cast iron car wheel has an endurance on the track almost wonderful, but if the steel is better, safer and as economical in the end, let it be adopted by all means. At any rate let us have the real wearing tests made under the cars, and then the economical questions are easily solved.—*Railway Times.*

NEW RAIL-LEVELING DEVICE.—The ordinary lever-bar used for lifting rails and sleepers in constructing and repairing the permanent way of railways, involves in its operation the labor of several men. To obviate this, an English engineer, Mr. De Bergue, has constructed a simple and compact tool, composed of a kind of shoe combined with a bar pivoted at one end, and at the other furnished with a screw by which it may be raised relatively to the shoe. The instrument with its bar depressed is thrust under the rail or sleeper to be raised, and the screw is turned until the bar has been forced upward sufficiently to bring the superincumbent parts to the required position. Those portions of the apparatus subjected to heavy strains are made of steel, and the working surfaces are hardened so that it cannot easily get out of repair.—*Railway Times.*

THE SLIDING OF CAR WHEELS.—An experiment has been made at Munich, for the purpose of determining if a railway-carriage wheel rolls regularly without sliding, so that by recording the number of revolutions of a wheel, the circumference of which is known, the distance accomplished could be accurately ascertained. The difference between the measurement by mathematical instruments and that obtained by noting the revolutions of the wheel, was found to be no more than 1-68,000 of the whole.

WOODEN WHEELS.—Mansell's patent wheels for railway carriages are fast coming into general use. They have already been adopted by the London and North-Western, Great Western, Midland, Great Northern, Great Eastern, Metropolitan, and other English lines, and the Imperial Government has sanctioned their adoption on all the railways of Russia. It may not be generally known that Mansell's original patent was for securing the tire to the wheel by retaining rings, the fillets of which are turned to fit into corresponding grooves in the tires. The whole is secured by nuts and bolts. Between the tire and the boss, spokes are dispensed with by the insertion of stout close-fitting panels of East India teak wood, the oily nature of which preserves from oxidation the iron passing through it. For this purpose teak is superior to any other wood and it has further the advantage of never shrinking. The superiority of these wheels over iron ones is well known to all observant travelers, their special merits being absence of jarring, and also of noise.—*The Engineer.*

IRON TUBES FOR BOILERS.—There are many lines of railway on which iron tubes are found to answer as well as brass, if indeed, they do not answer better. We believe iron tubes are very largely used on the Lancashire and Yorkshire Railway, and with good succ ess. A single Birmingham house might be mentioned which has turned out 550 tons and upwards of iron tubes a month, and of these as many as 10,500 have been for locomotives, corresponding to perhaps sixty locomotives in number, although it is not to be supposed that a single house has gone on at the same rate for a year together, iron tubing, in that time, as many as seven hundred or more locomotives.—*Engineering.*

DURABILITY OF ENGLISH LOCOMOTIVES.—The life of a locomotive boiler has been found to be about 350,000 train miles, but this may probably on some lines go up to 400,000, or even 500,000 miles, as its wear and tear would depend greatly on local circumstances, and particularly on the chemical qualities of the water employed. Assuming that the life of the engine is determined by the endurance of the boiler, and that if, under favorable circumstances, it will last the 500,000 miles, then during that time the fire-box will probably require to be renewed at least three times, the tires of the wheels five or perhaps six times, the crank axles three or four times, and the tubes probably from seven to ten times.—*Herepath's Railway Journal.*

ANOTHER ALPINE RAILWAY.—Mr. Thomas Brassey, the railway contractor, has just completed his tour of inspection over the projected new railway from Innspruck, *viâ* Feldkirch, to the Bodensee, and that his opinion seems to incline in favor of the improved Fell system over the Arl mountain, instead of tunneling through it. We trust, however, for the sake of the shareholders, that there is no foundation in the report. Our own opinion of the Fell system is well known.—*Neue Freie Presse.*

CAR LOCKING IN ENGLAND.—Mr. Bentinck is about to bring under the notice of the House of Commons the practice adopted by railway companies of barring the windows and locking the doors of passenger carriages.

NEW BOOKS.

A TREATISE ON THE ART OF CONSTRUCTING OBLIQUE ARCHES WITH SPIRAL COURSES. By WM. DONALDSON, M. A. Cant., Assoc. Inst. C. E. London: E. and F. N. Spon, Charing-cross. For sale by D. Van Nostraud, New York.

The importance of works the object of which is to enable the practical man to proceed with mathematical accuracy in his business, without requiring to undertake the labor of studying pure mathematics, is more extensively acknowledged every day; whilst the continually increasing attention paid to technical knowledge by business men enables strictly scientific men to afford them the necessary theoretical aid with far greater facility than formerly. A very valuable treatise of the technical science class has just been issued by Mr. Donaldson, and will, doubtless, find a large number of patrons. The object of the author has been to arrive at a series of formulæ which would give the data necessary for the construction of oblique arches, without having recourse to any developments on a large scale, or which require skill in draughtsmanship.—He commences by explaining and demonstrating the properties of screw surfaces, and then proceeds to investigate the stability of oblique bridges, basing his investigations upon the assumptions—firstly, that the material can resist any pressure that can be put upon it; and, secondly, that for perfect security no force of shearing must be exerted upon any of the voussoirs. He explains that the forces acting on a voussoir are its own weight, a portion of the weight passing over the bridge, and the pressures on its beds. No force is exerted on the ends of a voussoir; in oblique bridges it is kept in its place by the friction on the beds. If there were no backing these forces must be in equilibrium; this is never the case where the live load is variable; they must, therefore, have a definite resultant.—We may resolve these pressures in three directions—vertical, parallel to the axis, and perpendicular to these two; the resultant of the vertical components will be eqal and opposite to the weight of the voussoir and the weight upon it, and in order that the horizontal components may satisfy the condition for perfect safety, their resultants must fall within the springing nearest to the bed to which they refer, so as to meet the material with which the bridge is backed up; also, since the pressures between the voussoir beds are mutual, the horizontal resultant of each pair must pass within each springing. He explains that the pressure at any point of a voussoir bed will act in the direction of a normal to the surface at that point, and will, therefore, lie in the normal plane to the screw line passing through that point, and will also be perpendicular to the revolving radius; and, therefore, its line of direction will be the line of intersection of the above normal plane, and a plane through that point perpendicular to the radius—the pressure at every point along this radius may be assumed to be the same. Having disposed of the question of the stability of oblique arches, Mr. Donaldson treats of the formation of templates. All the formulæ previously proved are collected together and their use explained, by working out the details of a bridge, an angle of forty-five degrees being chosen, because an instance in which the skew is very great gives the best illustration of the errors introduced by the approximate methods used. Throughout the book Mr. Donald-

son displays not only an intimate knowledge of the subject on which he writes, but also a great ability in imparting that knowledge to others. The work is strictly mathematical, but a knowledge of logarithms only, and this may be acquired in five minutes by those who do not already possess it, will suffice for the practical application of the formulæ.

SOUND. By JOHN TYNDALL, L.L. D., F. R. S., Professor of Natural Philosophy in the Royal Institution of Great Britain. Second Edition. Longmans, 1867. For sale by D. Van Nostrand, New York.

That this book should have reached a second edition so soon after its appearance, does not surprise us; for even to unscientific and unmathematical readers the abstruse subjects connected with natural philosophy become not only intelligible, but fascinating in the hands of Professor Tyndall. Since the death of Faraday, Tyndall has no rival as a master of experimental science, but even Faraday was not able to set forth his philosophy in the same picturesque and charming style as his successor. At once profound and popular, elaborate yet simple, abounding with beautiful illustrations, curious truths, and striking descriptions, these lectures are in the deepest sense instructive, and in the highest degree entertaining. The work has not only excited the attention of the scientific world generally, but has won admiration from all quarters. Besides the flattering reception it has met with in this country, the book has been republished in America, while editions of it have appeared in France and Germany.

The readers of these lectures must necessarily labor under no small disadvantage as compared with those who heard them delivered and witnessed the beautiful experiments by which the subject received elucidation. But this drawback notwithstanding, the reader will still find it a delightful task to follow Professor Tyndall through his curious labyrinth of reasoning and experiment in these pages. As he himself tells us, the true physical philosopher never rests content with an inference when an experiment to verify or contravene it is possible. Accordingly, the science of acoustics is here treated experimentally throughout, and the lecturer has endeavored so to place each experiment before the reader that he may almost realize it as an actual operation. No fewer than 169 illustrations of experiments accompany the text. In a word, to give distinct images of the various phenomena of sound, and to cause them to be seen mentally in their true relations, has been Professor Tyndall's task. He has not only succeeded, but has given the world by far the most complete and valuable contribution to the science and literature of acoustics that has appeared.—*The Building News.*

WROUGHT IRON BRIDGES AND ROOFS. By W. CAWTHORNE UNWIN, B. Sc., C. E. London: Spon, 1869. For sale by Van Nostrand.

This volume contains a series of lectures delivered at the Royal Engineer Establishment, Chatham, to the officers of the Royal Engineers under instruction there; and they were afterwards printed at the press of that establishment for private circulation. That they proved useful to those for whom they were originally intended we have no doubt, and they are now offered in a revised and rearranged form to a wider circle of readers. The author assisted Mr. William Fairbairn in some of his many researches, and the work is dedicated to him. It is illustrated with examples of the calculation of stress in girders and roof trusses by graphic and algebraic methods. The author has restricted the use of symbolic expressions as much as possible; and the work holds an intermediate place between practical and theoretical treatises.—*Builder.*

TRAITÉ DE l'EXPLOITATION DES MINES DE HOUILLE etc., etc. PAR A. T. PONSON, Ingénieur civil. 2nd Edit. by JULES PONSON. Liège and Paris. 2 vols. and Atlas.

This able and complete work on coal-mining has been somewhat improved in this its second edition. It is a tolerably exhaustive treatise from the Belgian point of view of its entire subject; not better, however, than one or two French works on the same which we have ere now reviewed in these pages.

In one of its most interesting and important sections, that on shaft-sinking through water-bearing strata of running sand and mud, we observe with surprise the absence of any notice of some of the most ingenious and effective contrivances that have advanced this part of the pit-sinker's art; and this is the more remarkable, as these are of origin so close to Belgium as to be almost Flemish. The Atlas of Plates published along with the first volume, which is all we have as yet received, is well executed, and the details, both as to coal formation and the tools etc. for working coal clear and good.—*Practical Mechanics' Journal.*

TRAITÉ PRATIQUE DE l'ENTRETIEN ET DE l'EXPLOITATION DES CHEMINS DE FER. PAR CH. GOSCHLER, Ing. etc. 8vo. Baudry, Paris. 1868.

This able systematic work upon the maintenance and working of railways, the two first volumes of which we reviewed a good while ago, has now reached its third and fourth, or concluding volume. The two first, it will be recollected, treated of the material and *personnel* of railways; now we have their keeping in repair and making good use of them systematized and treated of with clearness and great practical ability.

The work ought to be a *vade mecum* to every chief servant in the employ of every railway in Great Britain, or at least all such would profit by its study; but for this a translation into English must be had, and we see on the title-page *tous droits réservés.—Practical Mechanics' Journal.*

THE DISINFECTANT QUESTION. London: M'Corquodale & Co. 1869. For sale by Van Nostrand.

Who shall review the reviewers? This question arises to us because the little work before us is a reprint of a review published in a journal called the "Sanitary Record," upon a book on disinfectants recently written by Dr. Angus Smith. The work is virtually a defense of Condy's disinfecting fluid as against McDougall's powder, which the writer says, was partly invented by Dr. A. Smith, who is therefore likely enough to speak well of it. We do not like the tone or temper of the writer. But we must confess that our experience leads us to have a great faith in the value of permanganate of potash, whether it be sold by Mr. Condy or not. It is a most valuable disinfectant and deodorizer and when used in extremely dilute solution as a gargle, it is one of the best detergents in cases of sore throat and quinsey. Mr. Condy did not discover the permanganates, but he has certainly been instrumental in

introducing them into sanitary use. His "fluids" are essentially permanganates, and they are sold in a more convenient form and at a cheaper price than they can be obtained from the chemist. This fact may in some measure justify the writer's severe strictness on the slur which Dr. Smith has cast on "Condy's fluid."—*Scientific Opinion.*

A Practical Treatise on Mill-Gearing, Wheels, Shafts, Riggers, &c., for the Use of Engineers. By Thomas Box, London: E. and F. N. Spon. For sale by Van Nostrand.

All those of our readers who possessed of Mr. Box's "Practical Hydraulics" and "Treatise on Heat" (and no engineor should be without those handy little volumes) will gladly note the publication of the work before us. Mr. Box's books are what they profess to be, practical treatises clearly written and free from all abstruse mathematical formulæ; while they are, moreover, got up in good style, and are of a convenient size for reference.—The third of the series (at least we hope that there is to be a series), bearing the title at the head of the present notice is in no way inferior to those which have preceded it. It contains, within the space of some eighty odd octavo pages, five chapters, treating respectively of the standard unit of power, of wheels, of shafts, of riggers, and of keys for wheels and riggers; the work being concluded by an Appendix. In the chapter on wheels, Mr. Box gives rules for laying out and calculating the strength of teeth, as well as for proportioning the wheels themselves, these rules being accompanied by numerous tables, which materially facilitate calculation. Similarly the chapter on shafts comprises rules for calculating the transmitting power of shafts under different conditions, together with descriptions of various methods of coupling, useful notes on plummer blocks, bearings, &c., and a section devoted to the consideration of crank shafts for driving pumps and other work. The chapter on riggers or pulleys contains a clear explanation of the action of belts accompanied by some useful tables, and also rules for the proportion of riggers of various kinds; while the fifth chapter, though brief, is equally good in its way. Finally, the Appendix contains notes on the contraction of wheels in casting, the strength of shafts and gearing for screw propellers, and the theoretical strength of shafts.

We have now briefly indicated the contents of Mr. Box's useful little treatise, and we trust we have said enough to show that it forms a valuable addition to the practical engineer's library.—*Engineering.*

The Handbook of Iron Shipbuilding. By Thomas Smith, M. I. N. A. London: E. and F. N. Spon.

It is, unfortunately, seldom that we find men eminent in their profession willing to benefit the public by their knowledge which has been acquired during many years of varied experience. It is, indeed, too generally the fact that such knowledge is jealously guarded by them, and the only method by which any one can acquire it, is to undergo similar training, and, by picking up a "wrinkle" every now and then, gradually to become proficient. In this case, however, the author, with a generous independence that cannot be too highly praised, and which evidently arises out of a certain consciousness of superiority in his profession, has given to the public a large amount of exceedingly useful information which has hitherto been most religiously kept secret. Although this work is but small, it appears to teach everything that is requisite for building an iron vessel; not only giving dimensions and a full textual explanation of every part of a ship, from the keel to the framing of the hatches, but illustrating such of these explanations as may require it, by simple drawings that it is impossible to misunderstand.

In the second part of the work, besides tables of weights and results of experiments upon the strength of ships' beams, a vast amount of information is given as to the cost of vessels of various sizes, both as regards material and wages, every detail, even to the fitting up berths, being priced separately. The author has foreseen an objection that might be urged against the usefulness of giving prices—viz: that the price of labor varies considerably in different districts—by giving examples of the cost of labor on an iron vessel, not only in London, but also on the East coast, at Liverpool and on the Clyde; thus making this portion of the work equally useful for all parts of the country. From what we have said, it will be seen that we esteem this book very highly, and consequently we strongly recommend it to all shipowners, shipbuilders, inspectors, shipmasters, foremen, and all who wish to know how a ship ought to be built or what it ought to cost.—*The Artisan.*

Der Practische Maschinen Constructeur.—A German periodical for builders of machines, engineers and manufacturers, edited by Wilhelm Heinrich Uhland, engineer and director of the Technical Institute at Frankenberg-Chemnitz, in Saxony. This excellent periodical which has entered its second year, occupies itself principally and almost exclusively with the design and construction of machines of every description. It appears twice a month. Every number contains two large cartoons printed on both sides, with beautiful partly colored drawings of machinery of the best and newest construction, general plans as well as full and explicit details, so that no manufacturer or engineer of some experience will find any difficulty in making direct practical use of them. The whole character of this periodical is, in general, eminently *practical*, abstaining from all theoretical speculations, and plainly showing the way certain kinds of machinery or certain parts of machines have to be constructed and to be put in place to give complete satisfaction to makers and uses. As but very few papers of this character exist, and as the "Maschinen Constructeur" fills its task perfectly and steadily, we do not wonder that, in spite of the short time of its existence, this paper has already acquired a vast circulation in all industrial countries. Constructors, engineers and manufacturers, even when they are not acquainted with the German language, will find the various drawings of a high value.

What is Matter? By An Inner Templar. London: Wyman & Sons. 1869. The author of this work tries to answer a question on which, as we have no testimony of a crucial nature, it is absolutely impossible to decide. Whether the substratum of phenomena be regarded as either force or matter is really of no consequence. In either case when we go beyond the mere phenomenon—the mere sensual perception—we get into the

land of metaphysical abstractions. We may explain the mental impression which our senses have originated by supposing it to be the result of force or forces, or of matter having certain pre-supposed qualities, or by any other equally ingenious hypothesis; but we are as far from demonstration as ever. We confess we fail to see that "An Inner Templar" has advanced one step nearer the solution of the difficulty than those who preceded him. We have not been able, either, to ascertain very satisfactorily whether he advocates the existence of matter or force. We are quite willing to concede either to him, as being a convenient method of explaining things whose explanation we really know no more of than we do of eternity, or infinity, or atomicity. But we cannot admit, and the writer will agree with us in this, both force and matter. If in imagination we abstract force from matter, there is nothing left to conceive of. "An Inner Templar" has made no actual observations in physics, and he says he objects to mere hypotheses, as Newton did. We hope he does; but, certainly, of all the startling and wild hypotheses that we have ever met with, his own hypothesis of the origin of the salt of the sea is the most wonderful, since it is clearly evolved, like the camal of the psychologist, out of his moral consciousness. To assert as probable, that the salinity of the sea is due to the perpetual emanations of sodium, in the form of particles of matter (light) streaming from the sun, throws the old story of the "mill grinding salt" for ever into the shade. We fear a "Templar's" love of speculation drives him sometimes beyond the dull and commonplace, though still useful, region of facts. Nevertheless, we think his book contains a deal of interesting matter.—*Scientific Opinion.*

WORSSAM & CO.'S ILLUSTRATED CATALOGUE OF WOOD-WORKING MAHINERY, OAKLEY WORKS, KING'S ROAD, CHELSEA. Folio, 1869. Illustrated.

This is one of the most copious, complete, and handsomely got-up trade catalogues of any British tool-making establishment that we have seen. Dimensions, weights, speeds, power to drive, work done per hour, &c. by most of the tools are given, and the Catalogue is really a very good and valuable practical guide to wood-working machinery of the best and most recent descriptions.

Although by title limited to wood-working machine tools, in reality it is still more comprehensive, and embraces punching-presses, crab and crane machinery, marble-sawing and grinding machinery, mortar mills and several others, which the issuing house have made their specialities.—*Practical Mechanic's Journal.*

THE STEPPING STONE TO ARCHITECTUE. By T. MITCHELL. Longmans. For sale by D. Van Nostrand, New York.

This little book forms one of what the publishers designate their "Stepping Stone to Knowledge Series," addressed to the young. It may be called a Catechism of Architecture, after the manner of the well-known Pinnock, being a series of questions and answers on the history and different orders and styles of architecture, ancient, mediæval and modern, "compiled with the view of creating a taste in the mind of the young for the noblest of the arts."—The publication, however, may also prove serviceable to some who are more advanced, since it gives upwards of a score of plates, and about fifty figures taken from "Gwilt's Encyclopædia of Architecture."—*Building News.*

A DICTIONARY, PRACTICAL, THEORETICAL AND HISTORICAL, OF COMMERCE AND COMMERCIAL NAVIGATION. By the late J. R. M'CULLOCH. With a biographical notice. New edition by Hugh G. Reid. Longmans. 1869.

This is a new and enlarged edition of a standard work, containing not less than 1,600 pages of matter. It is well spoken of by the English authorities.

INVENTORS' AND MANUFACTURERS' GAZETTE. E. H. SALTIEL, New York. This is a new dollar monthly, containg ten pages of text and many wood engravings.

MISCELLANEOUS.

JOHN A. ROEBLING.—Mr. Roebling was by birth a Prussian. He was a distinguished pupil of the Royal Polytechnic School of Berlin. The subject of his thesis, upon graduating from that institution, was "Suspension-Bridges"—a subject which made his after life famous, his death glorious, and which will give to his memory a fullness and freshness that cannot pass away. After having been engaged for three years, in accordance with a Governmental regulation, upon the public works in Germany, he emigrated to America. Arriving at Pittsburg, he settled upon a small tract of land, and devoted his attention for a while to agricultural pursuits. About the year 1830, the onward movement in the tide of American engineering affairs set in with all its force, and the young agriculturist was taken up by the first incoming wave. The plough and the harrow, the scythe and the sickle must needs give way to the compass and level, the rod and the chain. He was employed for some time on the various canals and other works at that time being carried on in every direction. With great forethought, he commenced the manufacture of wire-rope, doubtless instigated thereto by a recollection of his early love of the subject of suspension-bridges. The year 1844 records his first work of that class—to wit, the construction of a wooden aqueduct across the Alleghany River, which he carried out on the wire-rope suspension principle, with great success. The construction of the suspension-bridge over the Monongahela at Pittsburg, the site of his early agricultural labors, followed. The erection of suspension-brigdges in various localities so far enlarged his experience as to induce him to undertake the apparently impossible task of spanning the Niagara, near the falls, with a railway suspension-bridge. This, his greatest achievement, was completed in 1855, and, for boldness in conception, economy in construction, and proportionate strength in all its parts is, perhaps, unsurpassed by any engineering work of modern times.

His designs of the East River Bridge, the plans of which he had thoroughly matured, and which have withstood the test of the severest criticism at the hands of the ablest engineering talent of the country, are left as the last, and perhaps the greatest, monument of his engineering skill in coping with physical obstacles that to other less bold and comprehensive minds would have proved insurmountable. In the crypt of St. Paul's Cathedral is a simple slab that marks the tomb of its great designer, Sir Christopher Wren. Upon the slab are inscribed, in effect, these words: "If you would

seek his monument, look around you." Thus it is with John A. Roebling; his works are an imperishable monument to his memory—*Engineering and Mining Journal.*

THE GREAT EASTERN.—When the eminent engineer, Brunel, built the Great Eastern, he expected to begin a new era in commerce. He supposed his vessel would carry freight and passengers cheaper and more expeditiously and comfortably than other vessels, and that he should work a revolution in shipbuilding and trade. Her first voyage to New York was a failure. She seemed to be an utter failure, and good for nothing. Poor Brunel died of chagrin and disappointment.—*Exchange.*

This is a specimen of the information given to the public about this wonderful ship, by commercial newspapers. Brunel conceived the idea of the Great Eastern, and arranged her double propelling power, but he did not build her, nor did he, in a naval architectural sense, design her. This was Scott Russell's work. That she will carry freight 100 per cent more cheaply than smaller vessels, when fully loaded, is not questioned by experts, and has in fact been demonstrated by the results of other ships of different sizes. The Great Eastern will hold eight times the freight and encounter only four times the resistance, at a given speed, of a vessel of half her length, breadth and depth. As to carrying passengers more comfortably—she has always demonstrated this, except in one case, when she was so ballasted as to roll abnormally. Any ship can be served so. We have sailed as quietly upon her, in mid ocean, as upon Long Island Sound steamers in average weather, and at a time, too, when the vessels passing the Great Eastern were pitching so much as to cause general sea-sickness. The Great Eastern was never filled nor never run on the route for which she was built. It is not probable that the "Scotia" would pay between Boston and New York, immense as the traffic is. How was the first voyage of the ship to New York a failure? We made that voyage in good average time, taking a long detour; and no one was seasick, though there were two days of heavy weather. The good-for-nothingness of the Great Eastern has been demonstrated by her laying three cables and uniting two continents—a work that would not have been done without her. Finally, Brunel died before she was launched, and consequently not in consequence of her unprofitable voyages, which were, by the way, the result of bad management. We commend these considerations to the penny-a-liners who periodically pitch into the Great Eastern.

THE BRITISH TELEGRAPH BILL.—The bill for the purchase of the telegraphic lines throughout Great Britain is a measure of great importance. The Government purpose extending telegraphic communication to the suburbs of all the large towns, to all the second-rate towns having railway stations, and to places in which at present there are neither telegraph nor railway stations. It is contemplated to serve, under the new arrangement, 3,376 places, instead of 1,882 now served by telegraphs and railways, and to have 842 branch offices, instead of the 247 existing at present. There is now one telegraph office to every 13,000 of the population; the Government will have one office to every 6.000 of the population. They propose, likewise, the creation of offices of deposit, every letter-box and every pillar-box being such an office, where messages will be received and sent to the telegraph office to be forwarded to their destination. The wires are to be brought into the money order office in every town and district, thereby bringing the telegraph into the center of a population, instead of its remaining, as it frequently does at present, in the outskirts. And they contemplate extending in many places the number of hours during which the telegraph will be accessible to the public. It is proposed also to have one uniform tariff of 1s. for 20 words. The basis of the agreement entered into, under an act passed last year, for the transfer of the lines to the Government, was that a sum amounting to twenty years' purchase of the net profits of the various telegraph companies up the 30th of June of last year should be paid to the proprietors of those undertakings. On this basis the amount to be paid to the companies is over $28,500,000 gold, but other expenses will swell the total cost to $33,500,000. It is expected that the lines will yield a gross revenue close upon $3,500,000, and the expenditure will be nearly $2,000,000, showing about $1,500,000 net profit—enough to pay the interest upon the purchase money and leave a surplus of fully $250,000. The number of inland messages for the year ending last December was 6,000,000, upon which number it is reckoned there will be an increase for the first year of at least 2,500,000. Much of this increase is expected to result from bringing the telegraph nearer the center of the population; experience, both on the continent and in England, having shown that wherever telegraph facilities are by this means placed within easy reach of the people, a large increase on the number of messages is certain to follow. It is noteworthy that, contrary to the opinion of some of the most experienced engineers, the Government, in the estimates, have calculated the life of a cable at fifteen years, and have therefore provided for replacing all the cables at the end of that time.—*Tribune.*

THE DARIEN CANAL—AN OLD PROJECT.—The project of uniting the two oceans by a cut across the Isthmus of Darien, is not a new or a modern one. In 1528 a route for a canal was examined by two Flemish engineers, by the orders of Philip II of Spain, but finding insuperable difficulties, the project was abandoned. In England the project was revived in the latter part of the seventeenth century. In 1826, Domingo Lopez, of New Granada, explored a route for a canal 44 miles in length, between Panama and Portobello. Another survey was made in 1827, under the orders of General Bolivar, by two English engineers, Lloyd and Falmark, who concluded their labors in 1829. The only result of their labors was proving the possibility of either a canal or railroad between Panama and Chagres. In 1843, the French government sent out MM. Garella and Courtines to make explorations. They reported in favor of a canal passing under the dividing ridge of the Ahogayegua by a tunnel 125 feet high from water level, and 17,390 feet long.

NAPOLEON AND THE ENGINEERS.—The Emperor Napoleon in his early days was an enthusiastic student of engineering science and an engineer of no mean acquirements; and since his elevation to the throne has shown himself constantly the friend,

patron and promoter of all ingenious inventions, and especially of all enterprises embodying the science of construction in public ways and works of all kinds. It is no mere empty compliment, then, that has been offered him by the London Institution of Civil Engineers in electing him an honorary member of that body; and the cordial reception which the Emperor gave the Committee who bore to him official information of it, meant, doubtless, more of genuine pleasure and cordiality than could be found in most international forms of courtesy.—*Y. Y. Times.*

MORTON'S EJECTOR-CONDENSER.—This novel appliance to the steam engine (described and illustrated in Van Nostrand's Magazine, No. 3, p. 225), is making rapid and extensive progress amongst engineers, mine owners, and others. Orders for the condenser and for licenses to manufacture it are being received from all parts of the United Kingdom. No fewer than four condensers were sent off last week to meet as many orders. One has lately been applied to a pumping engine at a colliery belonging to Messrs. Wilsons & Co., of Summerlee Ironworks, and the consumption of coal in six hours was immediately reduced from 56 cwt. to 33 cwt. A more striking instance of economy of fuel effected by using a Morton condenser is that afforded by an engine to which the condenser was applied, near Dalry, in Ayrshire. The consumption of fuel was reduced one-half. So satisfied is the manager of the works (Messrs. Merry and Cunninghame's) with the work done by this condenser, that it is intended to apply the apparatus to several other engines. It has been applied to a Clyde-built screw steamer, lately purchased for the Pontifical Marine, and Messrs. Day & Co., Southampton, have just built a splendid steam yacht, to whose engines it has been applied. In this instance the condenser has been constructed of finely polished gun-metal. —*Engineering.*

WELDED BOILERS.—A contract was recently let to a Belgian firm for the making of twenty boilers thirteen feet long and three and a half in diameter—the whole to be of half-inch plates, and to be *welded* throughout. No English firm would take the contract.—*Exchange.*

It would be interesting to know whether these boilers are to be welded by Bertram's gas welding process or some modification of it. We can hardly imagine how a perfect job can be made otherwise. We have seen at Woolwich a complex boiler completely and soundly welded by this process.

MR. ISHERWOOD AND GENERAL GRANT.—Speaking of the President's nomination of chief engineer James W. King to be chief of the Bureau of Steam Engineering, "in place of Isherwood, whom I desire removed," the Engineer says: "We are sorry that Mr. Isherwood has been removed. He was the right man in the right place as far as England was concerned."

SHIPPING OF LIVERPOOL.—The quantity of shipping for sale in the port of Liverpool now amounts to the enormous aggregate of 124,788 tons, thus classified:—Colonial built sailing ships, 39,510 tons; British built ditto, wood, 18,464 tons; ditto iron, 5,266 tons; foreign built, sailing ships, 10,943 tons; new sailing ships, iron and composite, 4,590 tons; screw steamers, 38,180 tons; paddle steamers, 7,835 tons.

MARINE ENGINES.—Messrs. Maudslay, Sons and Field, are completing three pairs of 800-horse power engines for foreign governments. Messrs. John Penn and Son are actively engaged upon the 1200-horse power engines of the Sultan—copies in every respect of the engines of the Hercules. The great crank shaft was forged by Messrs. Rigby and Beardmore, of the Parkhead Forge, Glasgow. It has turned out, in the lathe, as sound a forging as any ever made. Its weight, in the rough, was nearly 35 tons.

BOILER EXPLOSIONS.—No one doubts that a series of comprehensive experiments conducted by our most competent experts, and costing say $100,000, would develop the causes and remedies for these disasters; yet boiler owners go on blowing up millions of money—not to speak of lives—every year, without spending a cent or making a movement towards a radical cure. So long as the causes of explosions cannot be proved and demonstrated to be simple and accessible, rather than mysterious and remote, so long will there be excuses for mal-construction and mal-practice.

AERIAL NAVIGATION.—Upon the heels of the meeting of the British Æronautical Society, which developed little but hopes based upon failures, we have news from California that the great problem is solved. Let us hope so. At the same time, it is difficult to see, with the light we now have, how all the talent, patience and money expended in this direction in England, can have so utterly missed the great possibilities upon which the California inventor has so easily seized.

OCEAN TIME OF THE "DAUNTLESS."—The American yacht "Dauntless," Vice Commodore James G. Bennett, jun., recently made the run, from New York to Queenstown, in 12 days 17 hours 6 min. 12 sec., and beating the time of the "Henrietta" in her famous ocean race with the "Fleetwing" and "Vesta." The "Dauntless" experienced heavy weather the entire voyage.

AMERICAN RUNNING GEAR ABROAD.—An English firm of coachbuilders announce that they are prepared to build light carriages on wheels imported from America. Now that this innovation has been made it is just possible that the principle of light wheels will be applied to the construction of carts and wagons used in agricultural districts.

DUTY OF CORNISH ENGINES IN ENGLAND.—Eighteen Cornish engines were reported in April. These consumed 1,468 tons of coal, and lifted 11,700,000 tons of water ten fathoms high. Average duty, 53,700,000 lbs., lifted one foot high by the consumption of 112 lbs. of coal. Seven engines exceeded the average duty.

NEUTRALIZING MIASMATIC GASES.—The plan of neutralizing the effects of marshy extralations tried in the fens near Rochefort, and in Holland, with success, is about to be introduced into Lincolnshire. It consists in the cultivation of the sunflower on a large scale.

LARGE PUMPING ENGINE.—The "Scientific American" states that the third pumping engine for the Brooklyn Waterworks, now being built, will be the largest and most powerful pumping engine in the world, with the exception of one in Cincinnati.